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AN ASSESSMENT OF THE RECRUITING STATION LOCATION EVALUATION SYSTEM (RSLES)

by

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March 2000

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AN ASSESSMENT OF THE RECRUITING STATION LOCATION EVALUATION SYSTEM (RSLES)

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ABSTRACT

The purpose of this thesis is to assess the effectiveness of the Recruiting Station Location Evaluation System (RSLES) optimization model developed at Naval Postgraduate School as a result of the OSD Recruiting Station Location Project. RSLES was designed to aid DOD decision-makers in determining the optimum number of recruiting stations, their geographic location and staff size. The optimization procedure attempts to maximize contract production subject to service budget constraints. This system integrates an Access database, a GAMS optimizer, and MapInfo graphics to provide a flexible environment to maximize production through market analysis and demographic information. This research applies RSLES to 39 Metropolitan Statistical Areas (MSA) under three different stationing scenarios and analyzes the output to determine the effectiveness of the model. The recommended station location actions of the RSLES model are compared to actual stationing decisions made by the Navy and Army in fiscal years 1999 and 2000. The comparisons show that applying the RSLES model could increase Army and Navy contract production by 3,938 high-quality accessions for all 256 MSA's in the U.S.

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I. INTRODUCTION

A. INTRODUCTION

Since the beginning of the All-Volunteer Force (AVF) in 1973, the U.S. Military has never faced recruiting challenges like it does today at the beginning of the 21st century. The economic prosperity of the 1990s coupled with undefined missions and a declining veteran population in the general civilian community as well as in Congress, has created a unique challenge for military recruiting commands. In 1998, the Navy missed its annual recruiting goal by 6,900 sailors, forcing it to lower quality standards and increase spending on recruiting resources. These Changes enabled Navy to attain the 1999 recruiting mission. The Army missed mission attainment by 800 soldiers in 1998 and suffered an additional recruiting shortfall of 6,000 of in 1999 (Scarborough, October 1999). Military recruiting challenges have been amplified by the failure of the Air Force to reach its recruiting goal the first time in 20 years. Historically, the Air Force has been the only service that has not worried about accomplishing recruiting goals. However, 1999 saw the demise of this comfort level and forced the Air Force to launch a national advertising campaign to entice young men and women to join their ranks. Unfortunately, the "Aim High" service fell short of its 1999 mission by 1,700 airmen (Philpott, October 1999).

The implications of missing goal are being realized at every level of the nation's political leadership, from the President on down through Congress. Numerous efforts are

being tried to combat declining recruitment. In fiscal year 1999, 800 additional Navy recruiters and 176 Navy recruiting stations were added throughout the nation in response to past research that shows an increase in recruiters results in an increase in contracts.[1] Other factors proven to affect enlistment include advertising, relative pay, and educational benefits. Other policy changes were made to increase Army College Fund benefits to $50,000, to establish signing bonuses for new recruits who shipped to boot camp prior to October 1, 1999, and to implement significant pay raises for all service members. Another goal of the pay raise was to increase retention thereby decreasing recruiting requirements (Scharnber, September 1999). Even though more than $1.8 billion was spent in fighting the recruiting battles in fiscal year 1999 (Stone, October 1999), this did not produce the required number of new recruits. As the battle rages, the expenditure of even more funds on recruiting resources is expected in fiscal year 2000. The goal of this thesis is to determine the validity of a model developed to aid decision-makers in determining the optimum placement of additional recruiting resources.

B. BACKGROUND

Recruiting by individual services has been the method utilized to staff the United States Armed Forces since the inception of the AVF. Although each service accomplishes this task in its own way, each branch is devoted to recruiting high quality

[1] As of 31 January 2000, the total number of Navy recruiters is 4500 and Army recruiters is 6117. The Navy has 1421 recruiting stations whereas the Army has 1656.

men and women to meet its quantitative, qualitative, and program needs. The command structure designed to facilitate the recruiting process is similar for each service. At the headquarters level, the Commander, Navy Recruiting Command (CNRC) and the United States Army Recruiting Command (USAREC) establish policy for their recruiters throughout the nation. The Navy is then broken into four regions which coincide with their geographic responsibility: Central, North (Northeast region), South (Southeast region), and West. These four regions incorporate 31 Navy Recruiting Districts (NRD) that cover all 50 states and Puerto Rico. The Army structure, utilizing Battalions vice NRD's, is similar to that of the Navy. Each NRD/Battalion is responsible for the direct management and contract attainment of a cadre of recruiters who are distributed to individual stations. Recruiting stations are primarily used to conduct routine business such as phone calls for applicant prospecting, meeting with personnel in the Delayed Entry Program and processing paperwork on potential recruits.

C. MODEL ORIGIN

The influx of new recruiters coupled with a recent Commander, Navy Recruiting Command (CNRC) policy mandating a minimum size of two recruiters per station and a maximum size of four has caused the need to open 177 new Navy recruiting stations nationwide in 1999 and 2000. Because of the multifaceted challenges of recruiting in today's society, it is even more important to accurately predict the effects of various factors on enlisted contract production in order to improve decisions involving recruiting station location and recruiter assignment. Incorporation of these various factors in the

decision making process is vital to the determination of how much production can be projected for a given geographic area. The geographic location of recruiting resources is therefore considered to be of strategic importance.

Factors affecting station location decisions differ at each level of the decision-making process. The NRD/Battalion level's primary concern is maximizing production whereas the Army Corps of Engineers (ACOE), which controls the acquisition of commercial offices, is predominantly interested in minimizing cost. Currently, modeling tools that are utilized to track production and aid in decision making include the Navy's Standardized Territorial Evaluation and Analysis for Management (STEAM) by the Navy, and the Army's Automated Territory Alignment System (ATAS). In the Defense Authorization Act of 1996, Congress developed *Sec 32, Study Regarding Joint Process for Determining Location of Recruiting Stations.* This authorization directed the Office of the Secretary of Defense (OSD) to award funding for the development of an optimization model for locating recruiting stations within specified regions and assigning recruiters to each station (Force Management Policy, 1996a). OSD funded a project at the Naval Postgraduate School to develop enhanced models for assessing alternative geographic location for recruiting stations. The optimization model developed by Naval Postgraduate School for OSD aims to maximize production (for a given user-defined budget constraint) when determining optimum station locations within a defined metropolitan area.

Although recruiting stations conduct routine business, they also serve as a means of advertising for the Armed Forces and as a facility for "walk-in" traffic. For these reasons, location within easily accessible, densely populated areas is vital to success. Extensive research has been conducted on estimating enlistment supply models with a consistent finding that additional recruiters in a given area tend to increase the numbers of enlistments (see for example Warner, 1990). However, the optimum location for assigning the additional recruiters is an important piece of the successful recruiting puzzle. Identifying the optimum zip code within a specified geographic area is the challenge undertaken by the OSD model. Currently, each service has its own means of determining the optimum station location and the appropriate recruiter assignment factor. All services utilize some form of mathematical models; however, none of them incorporate the effects of other service recruiters on their production attainment, nor the location effect of stations on production. Upon completion, the OSD model will integrate the effects of all services on each other and will be a tool that can be utilized DOD-wide.

D. OBJECTIVE AND RESEARCH QUESTIONS

This thesis will analyze the effectiveness of the optimizer model embedded in the decision support system (DSS) developed as a result of the OSD Recruiting Station Location Project. The system, Recruit Station Location Evaluation System (RSLES), was designed to aid DOD decision-makers in determining the optimum number of recruiting stations, their geographic location and staff size. The optimization procedure is based on achievement of maximum production within budget constraints. Our approach

will be to apply the RSLES model in 39 metropolitan areas around the U.S. In each case we will analyze the recommended locations at the zip code level generated by the model. We will intensively analyze five specific metropolitan areas and the Navy Recruiting Districts' specific decisions on new station locations within these five MSA's. Specific questions we will attempt to answer are:

1) Are the station actions completed by CNRC/USAREC supported by RSLES? If not, why not?

2) What is the estimated production from CNRC/USAREC actions compared to RSLES recommendations?

3) Is there a station alignment scenario (in RSLES) that generates greater predicted production than that obtained by CNRC/USAREC actions?

4) How much will RSLES potentially improve production? What is the opportunity cost of RSLES' recommendations?

5) Are there aspects of the "station location" issue that have not been addressed by the model?

6) Are there modifications that should be made to enrich the quality of output from RSLES?

Hopefully, this research will bring the RSLES model one step closer to becoming a useable tool for military recruiting decision-makers in the optimum allocation of scare recruiting resources. With recruiting production goals becoming increasingly difficult to attain, optimal use of resources is required to maintain fleet readiness.

E. SCOPE, LIMITATIONS AND ASSUMPTIONS

The scope of this thesis is to analyze RSLES from three perspectives: that of OSD's Joint Recruiting Facility Committee (JRFC); the ACOE; and the individual

service recruiting commands. This study will be centered on the station location model developed in response to the OSD Recruiting Station Location Project. Specifically, we will compare model outputs to actual decisions made at lower-echelon levels (battalion and district commanders) to evaluate the effectiveness of RSLES as a decision making tool. Focused interviews of key personnel in the decision making process also will be used to guide us in assessing the current RSLES product and in making recommendations for future model enhancements. Our analysis will consider only Army and Navy recruiting stations and their interaction and will be restricted to 39 metropolitan areas (metropolitan areas are defined by the Bureau of the Census (July 1999)).[2]

F. LITERATURE REVIEW AND METHODOLOGY

The Recruiting Station Location Evaluation System incorporates output from several separate but integrated efforts. In response to the OSD Recruiting Station Location Project, several Naval Postgraduate School students and professors began tackling separate issues of the problem. Hogan, Mehay, and Cook (June 1998) addressed the first portion of the model development process in a 1998 research project. Their research focused on the compilation of a multi-service database to incorporate variables assumed and ultimately proven to affect military recruiting production. Variables included in the data base are production, population, unemployment rate, per-capita

[2] Output from RSLES is provided at the zip code level, therefore, station locations will be considered as "joint" if stations are located within the same zip code (it is assumed they are in the same building). This factor is important in determining the amount of expenditures necessary to open or maintain recruiting stations. Collocated or "joint" stations are also factored into calculations for enlisted contract attainment.

income, and square mileage with all data broken down to the zip code level. Also included is the zip code of each recruiting office and the linear distance from each zip code to each station. Data at the zip code level is further aggregated to the metropolitan level.

Paul E. Martin (1998) developed a GAMS (Generalized Algebraic Modeling System) optimizer model called MS-LOCAL. Martin used an econometric model developed by Hogan et al. (1998) to create a cost model, which was integrated into MS-LOCAL. His mixed integer non-linear program was set up in two alternative ways: one that minimizes cost subject to production goals and one that maximizes production subject to a budget constraint.

The GAMS optimizer model was then incorporated into a geographic information system (GIS) by Houck and Shigley in a June 1999 thesis. The GIS mapping was based on MapInfo software and was developed to provide a flexible environment that leverages operational recruiting, market analysis, and demographic information for decision making in a visual format. The model is made up of four parts: (1) An econometric model for predicting productivity; (2) A cost model, estimated by Hogan et al. (1998) for measuring recruiter and station costs; (3) An optimization model for determining station locations; and (4) A DSS to integrate the models and their associated data. This model has been altered since its original conception to incorporate three services.

The authors believed that the fourth step in this process was to determine the effectiveness of the combined efforts of steps one through three. Due to limitations,

specifically the limit of choosing a maximum of ten candidate zip codes for a new station locations, user friendliness and graphic interfaces, RSLES is currently under modification. Effectiveness will be tested through real world application of the MS-LOCAL model, as revised by Professor Kevin Gue at NPS, at the metropolitan level and compared to actual decisions and recommendations made by the recruiting commands and district commanders.

G. DEFINITIONS AND DESCRIPTIONS

1. Metropolitan Statistical Area (MSA)

This study focuses on recruiting production at the metropolitan level. MSA's are incorporated in the database as defined by the Office of Management and Budget according to published standards[3] that are then applied to Census Bureau data. There are 258 MSA's as of 30 June 1999 (Census Bureau, 1999). A database built by Jarosz and Stephens (1999) aggregated all variables at the zip code level in the Hogan et al. database to the MSA level.

2. Enlisted Production

Enlisted production in this study is based on the annual number of high quality males who enlist (sign a contract) into a particular service. Enlistees are considered high

[3] The criteria for a city to be classified as an MSA are: 1) A central city with 50,000 or more inhabitants; 2) May incorporate geographic area (aggregation of counties) inclusive of outlying communities having a high degree of economic and social integration with that city; 3) Includes urban area of 50,000 people or more with total population of MSA being 100,000 people or more (75,000 in new England area); 4) May include more than one city; and 5) May cross state boundaries.

quality if they are high school diploma graduates, a high school senior, or someone with some college credits who score in Category I, II, or IIIA (percentile score 50 - 99) on the Armed Forces Qualification Test (AFQT). The primary military recruiting market is based on 17 to 21 year old males.

3. Delayed Entry Program

Prior to shipping to boot camp, prospective recruits are placed in the DEP until their boot camp departure date. The DEP program provides preparatory training to ensure new recruits are prepared mentally, physically, and academically for the rigors awaiting them in the boot camp setting. The DEP is also utilized as a tool to regulate training start dates in an effort to level-load boot camp accessions as well as follow-on schools.

Although a member of the DEP has initially sworn in to the military, they are not a guaranteed military accession. Numerous factors (i.e. medical, legal, drug usage, personal decisions) may affect the actual accession of DEP personnel. In this regard, attrition from the delayed entry program is a common occurrence. During the 1990's approximately 15 percent (Ogren 1999) of DEP personnel never met their boot camp departure date. In this study, production (or "net contracts") is based on the number of males who actually ship to boot camp, rather than the number that signs the initial contract and joins the DEP.

4. Recruiting Costs

a. Recruiters

The RSLES model estimates the marginal cost of an additional recruiter to be $11,415 per year (Hogan, 1999). The factors incorporated into this figure include expenses such as compensation, training costs, and out-of-pocket expenses for items such as applicant lunches and document costs. Recruiter salary is not included because it is viewed as a sunk cost that will be paid whether the sailor is on recruiting duty or stationed aboard a ship.

b. Recruiting Stations

The cost of a recruiting station includes a number of factors such as the lease, utilities and parking. This figure is generated for a single-service station and is adjusted when a facility is shared by more than one service. A joint facility reduces the cost to each service because each service shares the expense of common areas such as hallways, testing rooms and bathrooms. We must reiterate, however, that RSLES denotes a joint station as any single zip code that contains an Army and Navy recruiting station regardless of whether they are collocated within the same building. This fact may cause a slight misrepresentation in potential joint recruiting station costs.

5. Funding Process

Funding for recruiting stations originates with OSD. It is then allocated to the ACOE, who serves as the Executive Agent for all services. At this level, available funds

are broken down into three recruiting facilities programs: "Maintenance," "Existing," and "Reduction." Allocations for each program are then made to the four services for their further dissemination to individual districts and battalions. In general, the funding allocated at each level serves as the limit for spending. However, increased availability of funds in FY 1999 and FY 2000 for overall recruiting programs has allowed for all requested station location changes without the need for intense scrutiny by the NRD/battalions or the ACOE. Actual rental costs for recruiting stations come out of "Existing" program monies, while funding for new stations, relocations, expansions and upgrades is provided through the "Maintenance" program funds. The average rental cost for recruiting stations is $17 per square foot with a high cost threshold of $35, unless approved by the affected district or battalion. Although the "Reduction" program is established for closure of recruiting stations, the current climate of increased recruiting resources has rendered this program inoperative.

6. The Navy's STEAM Database

Standardized Territorial Evaluation and Analysis for Management is a Navy database maintained at CNRC that analyzes market demographics within a NRD. Historical production data for the Navy incorporated into the RSLES database was taken from the STEAM database. This database is used to generate quarterly statistics and includes variables such as number of recruiters assigned per station, zip code locations of existing stations and contracts attained per zip code. This database is currently utilized

within CNRC as a tool to track production as well as to assist in the determination of suitable recruiting station locations and allocation of assigned recruiters.

7. The Army's ATAS Database

Historical recruiting data and market demographics is contained in the Army Recruiting Command's Automated Territory Alignment System (ATAS) database. This database provides recruiting production information broken into 3 year ASAD averages by zip code as well as the number of recruiters assigned and the zip code location of each recruiting station. ATAS provides recruiting battalions with the capability to perform data analysis and management tasks in support of the Recruiting Market Analysis.

8. Recruiting Facility Management Information System (RFMIS)

The RFMIS database is maintained by the Army Corps of Engineers and the Joint Recruiting Facilities Committee (JRFC) and is used to report maintenance requirements for existing recruiting stations as well as proposed actions for the opening or closing of stations. This military-wide database includes the financial tracking and management of the listed actions.

H. ORGANIZATION OF STUDY

The remainder of this research project will be organized as follows. Chapter II reviews the literature relevant to the RSLES model. Chapter III provides the methodology utilized by this research team in the RSLES application and evaluation. Chapter IV presents the validation process of RSLES compared to STEAM and ATAS

recommendations for recruiting station locations in various metropolitan areas. Chapter V is an in-depth analysis of five MSA's and the differences between model recommendations and NRD/battalion station decisions. Chapter VI offers conclusions and recommendations for further research and development.

II. LITERATURE REVIEW

A. INTRODUCTION

A few studies have been conducted on recruiting station location over the past decade. The services, especially the Army and Navy, are particularly interested in assigning recruiters to stations located so as to maximize production. It is important to understand the factors that are used to make up the models to choose locations.

B. PREVIOUS MILITARY OPTIMIZATION STUDIES

Schwartz (1993) and Lawphongpanich (1992) developed models currently in use at the Navy Recruiting Command. Their research attempted to unify the recruiting station structure by creating models to solve two sequential problems. The first problem was to determine which recruiting stations should remain open and the second was to determine how many recruiters should be assigned to each open station. The objective function was to maximize the number of accessions. They specified their model using a mixed integer non-linear program and solved it by decomposing the optimization into four subproblems. These subproblems were solved sequentially and the solution produced near-optimal results within 10 percent.

Teague (1994) developed an optimization model to maximize production within an Army recruiting battalion in order to determine the optimum location and number of recruiters for each Army recruiting station. His model, called A-LOCAL, was designed to find the best stations in a downsizing environment. He selected candidate zip codes

from those zip codes with stations in them in FY94. A-LOCAL was formulated as a mixed integer non-linear program and solved using a heuristic technique. Contract production functions were estimated using Poisson regression. Data Envelopment Analysis (DEA) was used to identify only those stations that should remain open. DEA for a non-profit organization is an efficiency ratio equal to a weighted sum of outputs over a weighted sum of inputs. In this thesis, the efficiency ratio was calculated as maximizing the number of high-quality accessions produced by the station over the number of recruiters, market population, number of high schools, inverse of area, inverse of average distance from assigned zip codes to the station, average unemployment rate and average relative military pay. Two production functions were used in their study. The first is an aggregate of the average production in all zip codes at the battalion level. An average efficiency ratio was the result and then it was compared to the station's efficiency ratio with the intent of closing stations with below average efficiency ratios. The second production function was based on the remaining efficient stations (those equal to or above average within a battalion) which were used to calculate how many high quality enlistments the remaining alignment could obtain.

Our objective is to evaluate the Recruiting Station Location Evaluation System (RSLES). Houck and Shigley (1999) created a graphical user interface to incorporate the various elements of the RSLES model. They created the decision support system utilizing COTS software and integrated the modules in the RSLES model in a macro-architecture environment. RSLES integrates four separate modules. The mapping engine

is based on MapInfo Professional 5.0 and was selected for the mapping module due to widespread use among analysts in the recruiting commands. The database management system chosen was Microsoft Access 97 due to widespread availability of this Microsoft product. The optimizer module uses GAMS and incorporates elements of Martin's MS-LOCAL programming. The user interface module uses Visual Basic 6.0, which allows for event-driven programming. Houck's and Shigley's finished product (RSLES) chooses the configuration of recruiting stations and number of recruiters in a metropolitan area based on minimizing cost constrained by a target production goal.

Hogan et al. (1998) created a Navy Enlistment Supply Model to analyze the effects of the number of assigned recruiters and stations on contract production at the zip code level. They utilized historical production data (all service accession data at the zip code level by quarter) from FY95 to FY97. They believed that recruiters and station locations have a significant effect on the information and direct costs of application for entry in to the armed forces. For example, longer distances from the station to the market increases recruiter "windshield time" thereby reducing the amount of time recruiters have to prospect for new applicants. Stations promote Navy awareness, are "billboard" advertising and are like retail stores because they bring in "walk-in" traffic thereby decreasing information costs. Reducing these costs would increase the number of enlistments. Hogan et al. utilized zip code level demographics by collecting information from ATAS, STEAM, the Census Bureau and the Department of Labor. They ran non-linear regressions, fixed-effects models and a two-stage least squares estimator. They

estimated the effects of recruiters, stations, market population, unemployment, distance, area and per capita income on high quality production.

The results of the Hogan et al. study validated the effect of recruiters on enlistments. More specifically, they found Navy recruiters are more productive when located in stations that are close to high schools and in zip codes where there are Navy recruiting stations. Army recruiters were found to have a strong effect on Army enlistments as well as a positive effect on Navy enlistments. Different service recruiters in the same zip code had a small, but positive and statistically significant, effect on production, thus supporting the view that collocation of recruiters does not harm production. Higher travel costs, more specifically a ten percent increase in the average distance from the station to a zip code, were found to reduce accessions by 0.3 percent. Finally, they validated that zip codes with more affluent people have fewer enlistments, whereas higher unemployment rates aid in the recruiting effort.

Martin (1999) incorporated the Hogan et al. (1998) econometric database into a large-scale optimization model called MS-LOCAL (a multi-service location-allocation model). He developed two alternative objective functions: one that minimizes cost subject to production goals and a second that maximizes production subject to a budget constraint. He applied his model to various scenarios for the metropolitan areas of Jacksonville, Denver and Boston and generated the optimal allocation of resources in single-service and joint-service stations. Martin estimated that comparing his model's

results with the current recruiting station configuration could increase production by two to eight percent and decrease facility and recruiter costs by 10 to 32 percent.

Martin assigned alternative recruiter costs of $10K and $40K (the difference being the recruiter salary) and applied them to both the minimum cost and maximum production version of the optimization model for the three MSA's. The higher recruiter cost ($40K) led to a decrease in the number of recruiters in three of the six cases. The higher cost model required that four of six MSA scenarios have more collocated stations. Martin's logic in building the model is sound, but his results are questionable to experienced recruiting management. Achieving the same amount of accessions with a 50 percent decrease in the number of recruiters and 20 percent decrease in the number of stations does not make intuitive sense. We believe Martin obtained these results for two reasons: 1) The parameter estimate dealing with the effect of a joint station on Navy production needed to be checked for plausibility; 2) As Martin pointed out the MS-LOCAL model needed to be validated for errors in the data, for computational errors and for logic. The first reason caused the requirement for Navy recruiters and joint or total recruiters to decrease because the model indicated that an extra Army recruiter generated more additional Navy contracts than Army contracts. Generally, the model output demonstrated that the Navy needs fewer recruiters in common station boundaries than the Army in order to achieve its own production target.

III. METHODOLOGY FOR RSLES APPLICATION AND EVALUATION

A. PROCEDURE FOR MODEL APPLICATION

Our goal was to apply the RSLES model to a representative sample of the 256 metropolitan areas in the U.S. To this end, we completed applications to 39 metropolitan areas of various sizes and geographic locations where known station openings were planned for FY99 and FY00. The procedure to begin using the RSLES two-service model included collection of actual station location data from CNRC Code 335 (Rich VanMeter) and USAREC Facilities Coordinator Office (Teresa Monroe). This data included proposed new station locations and expansions by zip code and the number of recruiters to be assigned to each new recruiting station within the selected metropolitan areas.

Prior to running the model for a particular metropolitan area (MSA), the RSLES database was to set up as temporary files in Microsoft Access for a given MSA. Eight input files were necessary to run the application. All input files except one were broken down by individual zip codes. The exception is a file containing the three-year average of the total number of high-quality male accessions for each MSA (aggregated over zip codes). The main data file included information on station location, market population, number of high schools, whether a station is located in a given zip code, area, density, income, unemployment rate, urban and rural dummies and production adjustment dummies for both services. Three input files contained a list of all the zip codes within an MSA.

To reduce each model application to a feasibly-sized optimization problem, the remaining input files were then restricted to a sub-set of all zip codes in a given metropolitan area. To select the sub-set of zip codes, each zip code was closely reviewed for changes in station status and production history. Zip codes found to have no historical production and no existing recruiting station were eliminated. The remaining zip codes, referred to as candidate zip codes, then become potential locations for pre-specified station openings, closings or to be selected by the model during an optimization run.

Originally RSLES, as set up by Houck and Shigley (1999), allowed for only ten candidate zip codes per service. By recoding the GAMS code in the two-service model as displayed in Appendix E, we were able to run MSA's with as many as 65 candidate zip codes and still obtain optimal solutions in GAMS. To standardize the process, we attempted to give each MSA scenario 25 candidate zip codes as potential candidates for station actions. We eliminated zip codes with less than five quality DOD (all services) accessions per year in metropolitan areas with a market population above 50,000. Zip codes not meeting these guidelines were included if the MSA contained fewer than 30 zip codes, a station already existed in that zip code, or if that zip code had been selected by the local district (or battalion) as the location for a new station.

Once the candidate zip codes were selected, the final four input files were constructed. These files contained a list of candidate zip codes. The second input file included data for the cost of opening new stations for the Army and Navy, joint station

savings and the cost of a recruiter within each candidate zip code. The third file included data on location (latitude and longitude) of the centroid of a station's zip code, market population, number of Army and Navy recruiters and station status (open, close, choose) of the zip codes (selected by the analyst).

Once all input files were queried and candidate zip codes selected, the files were exported to a GAMS directory in text format. Microsoft's Notepad was utilized to correctly format and place headers over the required columns so RSLES could distinguish between data types. All input files were then checked for accuracy. One important requirement was that the same zip codes were listed in each of the MSA's files and candidate zip code files. Prior to running each application, one input file was modified to include the actual CNRC and USAREC decisions on proposed station locations. Table 3-1 shows the candidate zip codes for the Monroe, Louisiana, MSA, the corresponding longitude (llong), latitude (llat), the number of Army recruiters assigned (arec), the number of Navy recruiters assigned (nrec), the population size of 17 – 21 year old males (lpop) and the Army and Navy station status.

Table 3-1. Monroe, LA Candidate Zip Codes

Zip	llong	llat	arec	nrec	lpop	astatus	nstatus
71202	-92.05	32.39	0.00	3.00	1628	2	2
71203	-92.01	32.59	0.00	0.00	3465	2	2
71212	-92.07	32.52	0.00	0.00	0	2	2
71213	-92.04	32.53	0.00	0.00	0	2	2
71220	-91.91	32.87	0.00	0.00	1401	2	2
71225	-92.34	32.50	0.00	0.00	201	2	2
71234	-92.37	32.66	0.00	0.00	136	2	2
71280	-92.15	32.60	0.00	0.00	71	2	2
71291	-92.20	32.54	0.00	0.00	1737	2	2
71292	-92.20	32.39	0.00	0.00	1186	2	2
71227	-92.50	32.52	0.00	0.00	136	2	2
71238	-92.35	32.36	0.00	0.00	68	2	2
71201	-92.10	32.53	6.00	3.00	1263	1	1

The astatus and nstatus variables indicate the status codes for Army and Navy stations, respectively. They can be changed to reflect the scenario for each particular model application. If astatus or nstatus = 0 this indicates that the station in the zip code is to be closed. If astatus or nstatus =1 then a station should be opened if one does not already exist, or remain open if it already exists. If astatus or nstatus = 2 the GAMS model is allowed to choose whether to open or close a station in that zip code. We utilized this input file to run three different scenarios for each MSA, as will be discussed in the following section.

Each model is implemented through the General Algebraic Modeling System (GAMS) and uses CPLEX version 5.0 to solve the mixed-integer linear programming problems. The optimization procedure maximizes production for a given budget within a geographic location (MSA). The budget is calculated corresponding to the current

allocation of recruiters and stations, including an estimate for distance cost. The cost of a recruiter is a constant $11,415, of which $10,000 represents expenses such as training, laptop computers, telephones, copies of official documents and lunches for potential recruits (Soutter, 1998). The extra $1,415 is the cost of the recruiting space (square footage) per recruiter (Hogan, 1999). Army and Navy station costs are calculated using Hogan's (1999) cost model that estimates the cost of locating a recruiting station in a zip code with given demographic characteristics (e.g., population density).

Once the budget total is calculated GAMS calculates the predicted production based on the coefficients from the econometric model. GAMS then assigns each zip code to the closest station (where one exists or is proposed) in an effort to aggregate the assigned market area for each recruiting station. In this first submodel, location assignments are weighted toward the three closest candidate zip codes. A zip code's territory can be eventually assigned to any of these three candidate zip codes with a status code to open a new station or remain open. The second submodel fixes the weighted zip codes from submodel one into an integer value (in this case a 1 or a 0), so it can assign where all zip codes within the MSA belong to achieve maximum production. This zip code assignment value is a binary variable (either a one or a zero) for each zip code based on whether there is a recruiting station (or proposed station) in it. The second submodel chooses the best locations. The third submodel then chooses the number of recruiters for these best locations so as to maximize production within the total budget constraint. The GAMS code used in our assessment of the two-service RSLES model can be found in

Appendix E, where submodel one is referred to as PICKLOC, submodel two as PICKLOCS and submodel three as PICKRECRS.

B. RSLES MODEL APPLIED IN THREE SCENARIOS

1. The "New Recruiter Optimization" Scenario

The New Recruiter Optimization scenario accepts the current station alignment (as of 1998) and then adds recruiters based on recent CNRC decisions (in 1999 and 2000). The model chooses where to put the additional recruiters to achieve maximum production subject to the given budget and CNRC/USAREC station manning constraints. The model determines the allowable budget based on the number of allocated recruiters and new stations that were opened in the MSA. It then optimizes station location from the list of candidate zip codes that had been assigned a "choose" station status. The goal of the New Recruiter Optimization scenario is to test whether it can be used to assist decision-makers' location selections when opening new stations. In the current recruiting environment, the services are not closing stations, but rather are opening a large number of them. For example in Table 3-1, Monroe. LA has a 3-person station in zip 71201 that NRD New Orleans wants to keep open, thus the zip code status = 1. NRD New Orleans wants to open a new 3-person station somewhere in the MSA. Therefore, we include three recruiters in the first free zip code so the model can assign these recruiters to available zip codes (those where status = 2). This model allows us to compare

CNRC/USAREC actions in regards to station location versus recommendations from the optimization procedure in RSLES.

2. "Baseline" Scenario

The second model application is based on CNRC/USAREC decisions on current station alignment. These decisions refer to the local district/battalion commanders' decisions to modify station alignment by opening, closing and expanding stations. This model is used to find the estimated production within the given MSA as per the station alignment decisions made by CNRC/USAREC. In this instance, we change the status to 0 for all zip codes except where those current stations are located and those where the services decided to put a new station for FY99 or FY00. Current stations and proposed new stations receive a status of 1 for their assigned zip code. This application allows us to compare the New Recruiter Optimization model's predicted production with the production predicted from the CNRC/USAREC decision.

3. "Full Optimization" Scenario

The final application was to allow RSLES free reign in optimizing station location with the candidate zip codes in each MSA. In this scenario, the model is allowed to optimize station alignment and new resources without imposing any restriction on current station locations. For this scenario we change the status of all zip codes for both services to status = 2. The model in this case does not always reach a fully optimized solution. However, an option allows GAMS to solve within two percent of optimality. This escape

clause allowed us to stop the model if it had not successfully converged within 2 hours of run time. The "full optimization" application allowed us to compare estimated production from the Navy and Army "Baseline" scenarios with estimated production from an optimal station location scenario.

C. TYPES OF OUTPUT GENERATED BY RSLES

Table 3-2 displays demographic information for each of the 39 MSA's in the sample. Included in the table is the Region responsible for the MSA, as well as the population size and population category (small, medium, large) of the MSA. The number of zip codes assigned to each MSA and the number of candidate zip codes identified by the authors for each MSA is found in the last two columns. The 39 MSA's vary in size from Chicago with a market population of 488,520 to Wasau, Wisconsin with a population of 9,340. Chicago MSA also has the most zip codes with 354, while Monroe, Louisiana has the least with 13. We reviewed station changes in 11 of the 31 Navy Recruiting Districts. The MSA's from these 11 NRD's fall into all four recruiting regions, nine from the West Region, seven from the Central Region, 18 from the Southern Region and five from the Northern Region.[4]

[4] Although additional data was collected from the Northern Region we were not able to apply it to RSLES. The New York MSA was too large (506 zip codes) to run with a desktop personal computer and NRD New England did not open or plan to open any new stations in fiscal years 1999 or 2000.

Table 3-2. Demographic Characteristics of Selected MSA's

MSA	Region	Population	Population Category	# of Zips in MSA	# of Candidate Zips
Atlanta	S	156492	L	135	35
Greenville	S	56473	M	63	25
Columbia	S	38457	S	32	19
Charleston	S	33105	S	42	14
Augusta	S	28980	S	37	13
Syracuse	N	55418	M	112	26
Buffalo	N	72789	M	85	25
Albany	N	59093	M	137	25
Rochester	N	69328	M	123	32
Utica	N	19922	S	63	14
Chicago	C	488520	L	354	65
Oklahoma City	C	70314	M	95	24
Denver	W	135444	L	129	30
Orlando	S	88896	M	92	30
Jacksonville	S	54788	M	52	25
Melbourne	S	22503	S	29	19
Minneapolis	C	159232	L	215	50
Milwaukee	C	93609	M	96	31
Appleton	C	25744	S	36	9
Madison	C	34992	S	45	21
Wausau	C	9340	S	22	22
Nashville	S	64400	M	104	25
Louisville	S	60960	M	83	26
Chattanooga	S	24527	S	44	23
Knoxville	S	38287	S	66	24
Lexington	S	33655	S	36	18
New Orleans	S	79717	M	77	30
Monroe	S	11292	S	13	13
Shreveport	S	22641	S	42	19
Baton Rouge	S	35688	S	37	21
Little Rock	S	33120	S	52	24
Las Vegas	W	54259	M	51	25
San Francisco	W	380998	L	290	62
Sacramento	W	102341	L	119	30
Modesto	W	27419	S	26	26
Stockton	W	31455	S	29	29
Visalia	W	19750	S	34	34
Salinas	W	27255	S	28	28
Fresno	W	45784	S	64	24
Population Categories	S =	0 - 50K		**Regions**	N = North
	M =	50 - 100K			S = South
	L =	100K or more			C = Central
					W = West

The 39 MSA's were put into size categories based on market population. We designated a small MSA as one with population under 50,000, a medium MSA as having population between 50,000 and 99,999 and a large MSA as having population exceeding 100,000. Of the 39 MSA's 20 were designated as small, 13 were medium and 6 were large.[5]

Data obtained from each of the three RSLES model applications is then displayed as output in separate list files. The output of most interest to this research is total estimated production, proposed station location and recruiter allocation. Table 3-3 shows an example of model output for Appleton, Wisconsin. Production is estimated for each service and recruiters are assigned to each zip code location.

Table 3-3. GAMS Model Output for Appleton, WI

		Production	
	Army	81.623	
	Navy	32.884	
		Zip Code	
		54901	54952
# Recruiters assigned	Army	2.0	4.0
	Navy	2.0	3.0

In Table 3-3, GAMS predicts the number of high-quality contracts for one fiscal year. In this case, Army production is predicted to be 82 and Navy high-quality male

[5] We have data and input files on two other large MSA's but experienced input errors that could not be solved within the timeframe available.

accessions are predicted to be 33. Recruiter assignments for each individual zip code are also generated by the model.

To determine what changes are recommended by RSLES in station locations, we compare the output of the Baseline scenario to the output of the New Recruiter Optimization scenario. The output collected from this comparison can be found in the tables in Appendix C and Appendix D. Appendix C was developed in Microsoft Excel to allow for data sorting and graphing. The goal in Appendix C is to sort MSA's by geographic region, market size and aggregate zip code size for further analysis. Data displayed in Appendix C fits four categories: demographics, production, recruiters, and recruiting stations. The demographics table lists the NRD responsible for each MSA as well as the region within CNRC that each NRD falls under. Column 4 displays a population size category with S=less than 50K, M=50-100K, and L= greater than 100K. Column 5 shows the GAMS model feasibility with respect to the New Recruiter Optimization scenario. Solutions were either optimal or they satisfied RSLES tolerance limit set at 2.0 percent of an optimal solution. Columns 6 and 7 display the number of zip codes associated with each metropolitan area and the number of candidate zip codes identified by the authors, respectively. A three-year average of Navy and Army historic production is displayed in columns 8 and 9 followed by the total historic production for both services. The production table in Appendix C begins with the aggregated predicted production of high-quality male accessions for the Navy and Army Baseline scenarios from all zip codes within the given MSA. The total predicted production for both services

is also provided. These three columns are followed by the same information obtained from the New Recruiter Optimization and the Full Optimization scenarios.

The recruiter allocation table found in Appendix C compares the number of recruiters assigned in the Navy Baseline scenarios with those assigned in the Navy New Recruiter Optimization scenario and highlights (in column 4) if there are resources not assigned by the model. The omission of resources occurs if the budget is not sufficient to open an additional station or to pay for the additional recruiters. The last three columns in this table repeat the same type of data for the Army. The last table in Appendix C refers to the number of recruiting stations in the Navy and Army Baseline scenarios versus the New Recruiter Optimization scenarios for each service.

Appendix D displays the New Recruiter Optimization scenario zip code recommendations versus the Baseline scenario. This table displays, by MSA, the zip codes with current stations as well as proposed stations and shows the agreement or disagreement (in column 6) between RSLES recommendations and service decisions. Column 9 is a display of differing station actions between the Navy Full Optimization scenario and the Navy Baseline scenario. Appendix D is a simplified source to review differences between service decisions ("Baseline") and RSLES recommendations. In Chapter V we conduct in-depth analyses of five MSA's based on the output displayed in Appendix D.

IV. VALIDATING RSLES

> Verification is the process of measuring the product and process and comparing the results to the expectations. This feedback will hopefully be used in a variety of ways from making minor adjustments to the model to termination of the entire project. (Fought and Mackel, 1998, p. 6-148).

A. TWO-SERVICE SCENARIO

Our validation process involves verifying the production predictions of the RSLES model by comparing them to "real world" historic production. The "real world" in this case is the annual average of all services' high quality male accessions from every populated zip code within a MSA during fiscal years 1995 - 1997. This research analyzed 39 (or 15.2 percent) of the nation's 256 MSA's as a statistical sample. The data collected is used to determine whether RSLES achieves its objectives. We compare the historical to the estimated production obtained from the three scenarios for each MSA. Secondly, we review the differences between recruiting station location recommendations made by RSLES and actual location choices made by CNRC/USAREC. Model output regarding predicted production is reported separately for the Army and Navy as well as in a combined "joint" form.

The joint high quality contract production predictions for the 39 MSA sample are graphically displayed in Figure 4–1. The figure graphs the regression of predicted Navy and Army production on the actual historic production. The outcome of the regression is a coefficient of determination of 0.903. That is, 90.3 percent of the variation in the

estimated production from the New Recruiter Optimization scenario using the RSLES model is explained by the historic production in the 39 MSA's. As expected, there is a strong linear relationship between the two variables. In this case, joint predicted production (from RSLES) is the dependent variable while actual historic production is the explanatory variable. The Beta coefficient is .9908, meaning for every 100 accessions achieved predicted accessions increase by 99 (see Appendix C). At 38 degrees of freedom and a significance level of 99 percent, the critical t-value is 3.31, and the computed t-statistic for B_1 = 18.56. The null hypothesis of $B_1 = 0$ can therefore be rejected. However, the null hypothesis that $B_1 = 1$ cannot be rejected. The probability the observed difference between the sample (historic) value and the predicted value is due to mere chance is less than 1 percent.

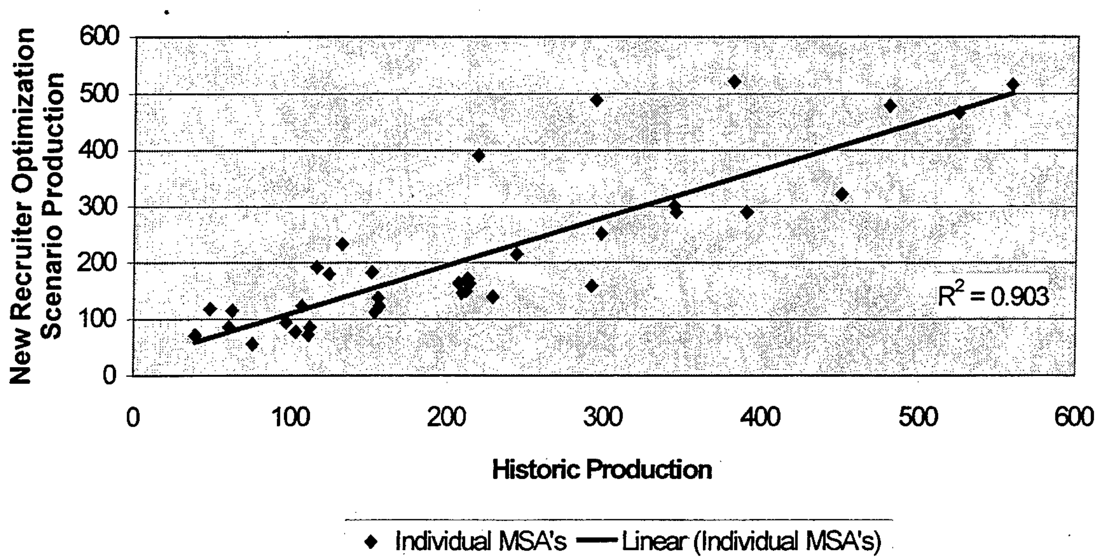


Figure 4-1. Joint High-Quality Contract Production

B. NAVY STATION AND RECRUITER ALIGNMENT AS COMPARED TO STEAM

To evaluate the potential for Navy recruiting we applied three different scenarios to RSLES. The "Baseline" scenario applies RSLES to candidate zip codes that represent the original station alignment and CNRC choices of new stations in fiscal years 1999 and 2000. The "New Recruiter Optimization" scenario applies RSLES to the original station alignment plus the option of finding station locations for additional recruiters assigned to the MSA. The "Full Optimization" scenario allows RSLES to recommend station alignment with no prior constraints except that station size must be between 2-4 recruiters. Table 4-1 shows the estimated Navy high-quality contract production obtained from RSLES (by MSA) for the three different scenarios. The last column in Table 4-1 represents the percent change in production between the Baseline and the Full Optimization Scenario.

The Navy Baseline scenario is based on the NRDs' stationing actions in each metropolitan area. Each district makes their resource allocation decisions utilizing STEAM as a planning tool. Each NRD is assigned a basic allowance (BA) of production recruiters. This BA is then adjusted downward based on a specified number of recruiters authorized to fill "off production" billets and the projected number of recruiters onboard at the beginning of the next fiscal year. The adjusted number of recruiters is applied to the STEAM model where it is multiplied by the market share and then divided by 100 to obtain the Recruiter Assignment Factor (RAF) for the NRD.

At the NRD level, market share is defined by weighting the total male senior population within NRD boundaries by 0.4, the primary workforce market (male 17-21 year-olds) by 0.2, and the secondary workforce market (male 22-29 year-olds) by 0.2. At the station level, market share is defined differently across CNRC. The traditional method is to calculate market share as mentioned above and weight it by 0.5. This 50 percent share is called the male population share. The other 0.5 of the equation is the all services accession (ASAD) share. The ASAD share is calculated in many ways. Some NRD's use 3 years of historical data, while others use 5 years or maybe only 5 quarters of data. Each share is then divided by the district total (the aggregate of all the recruiting stations' shares) and added together to obtain the recruiting station's market share. This market share is then multiplied by the district's adjusted recruiter number to obtain a station RAF.

The main point of these calculations is that market share determines RAF and the NRD decision-maker facilitates the process by inputting the number of recruiters STEAM uses for calculation. The plus-up in recruiters in FY99 and FY00 created higher station RAF's. Stations with RAF's above 4.0 were then reviewed for possible market splits to other stations or creation of new station territories. New stations are then usually selected from a particular zip code or a close conglomeration of zip codes with a RAF above 1.8 for a two-person station. Each NRD decision-maker would have to review the options using the market demographic information in STEAM.

Unlike CNRC's current resource allocation process, RSLES is a decision support system that recommends specific zip codes for location of new stations. STEAM is a large demographic database for use by decision-makers in conjunction with corporate knowledge to assist in choosing new station locations.

For the 39 MSA sample, the New Recruiter Optimization scenario recommendations (column 2 in Table 4-1) increase the number of high-quality male accessions by 59 over the Navy Baseline scenario based on STEAM data (column 1 in Table 4-1). This represents an increase in production of 1.59 percent. If we extrapolate this percentage improvement to all MSA's in the U.S., we could expect 387 additional high quality accessions per year if new stations were opened under RSLES guidance as compared to STEAM. In other words, this is the improvement achieved if we were to use RSLES to realign the additional recruiters.

If the Full Optimization scenario is implemented, RSLES predicts an increase of 218 high quality accessions in the 39 MSA sample. This represents an increase in production of 5.64 percent over the Navy Baseline scenario (column 3 vs. column 1 in Table 4-1). Extrapolating this percentage difference to all MSA's in the U.S. yields 1,431 additional high quality accessions per year. Increased production of this magnitude makes the RSLES option very attractive, and could help to eliminate 2.5 percent of annual Navy recruiting shortfalls based on an annual goal of 56,000 recruits. However, consideration must be given to the costs of wholesale station changes such as disruption of local recruiter practices and subsequent production decreases in the short term. In our

sample alone, to maximize production with the optimal station alignment, CNRC would have to close 105 existing stations and open 229 in new locations (see Appendix D). The 105 closings represent 52.5 percent of the original 221 stations. The Full Optimization scenario recommends a total of 345 recruiting stations, of which the 229 required openings represent 66.4 percent of the total. An interesting model output is that of the 779 recruiters currently assigned, 540 (69.3 percent) would require relocation (of which 485 recruiters would change station locations and 55 recruiter billets could be deleted).

Table 4-1. Navy High-Quality Contract Production

MSA	Baseline Scenario	New Recruiter Optimization Scenario	Full Optimization Scenario	% Change Baseline to Full Optimal
Rochester	37	37	46	24.3%
Salinas	19	20	23	21.1%
Nashville	53	55	62	17.0%
Albany	25	25	29	16.0%
Knoxville	37	37	42	13.5%
Syracuse	52	52	59	13.5%
Stockton	45	52	51	13.3%
Minneapolis	92	93	103	12.0%
Lexington	34	34	38	11.8%
Chattanooga	27	27	30	11.1%
Chicago	583	632	645	10.6%
Atlanta	189	189	203	7.4%
Louisville	54	56	58	7.4%
Greenville	57	57	61	7.0%
Madison	29	29	31	6.9%
Visalia	30	30	32	6.7%
Modesto	46	46	49	6.5%
Monroe	32	32	34	6.3%
Milwaukee	128	129	135	5.5%
Las Vegas	114	112	120	5.3%
Little Rock	79	79	83	5.1%
Augusta	40	39	42	5.0%

MSA	Baseline Scenario	New Recruiter Optimization Scenario	Full Optimization Scenario	% Change Baseline to Full Optimal
Jacksonville	100	100	105	5.0%
Shreveport	63	63	66	4.8%
Baton Rouge	63	64	66	4.8%
Columbia	49	49	51	4.1%
New Orleans	173	174	180	4.0%
Charleston	54	52	56	3.7%
Denver	217	215	224	3.2%
Orlando	157	158	162	3.2%
Appleton	33	33	34	3.0%
Sacramento	124	125	127	2.4%
Fresno	50	52	51	2.0%
Oklahoma City	211	208	215	1.9%
Buffalo	83	83	84	1.2%
Utica	10	10	10	0.0%
Wausau	18	18	18	0.0%
San Francisco	385	377	379	-1.6%
Melbourne	53	51	52	-1.9%
Total	3645	3694	3856	5.8%

We recommend those districts that own an MSA listed in Table 4-1 that experience a 10 percent or better increase in production, from the Baseline Scenario to the Full Optimization Scenario, to review the station changes listed in Appendix D. In Rochester, New York nine more high-quality male accessions per year represents a 24.3 percent increase in production. On the other hand, the RSLES model should be ignored for MSA's in Table 4-1 that experience a production gain of less than 2 percent. Holding all else constant, cities such as San Francisco and Oklahoma City are already producing about the best they possibly can.

The Central Region experiences the largest increase in high-quality production under the RSLES model. Furthermore, the potential 5.0 percent increase in production in

the Central region is primarily attributed to the production increases within the Chicago MSA. The Full Optimization scenario increases production by 9.2 percent in the North region. This finding is significant in that the sample includes five MSA's from the North region, all of which are in NRD Buffalo's territory. To achieve the 9.2 percent increase, NRD Buffalo would have to open 20 stations and close eight, increasing production by 21 high quality contracts per year.

The station actions recommended by RSLES in NRD Buffalo are shown in Table 4-2. The five MSA's in which NRD Buffalo made station changes during fiscal years 1999 or 2000 are listed in column 2 of Table 4-2. The zip codes listed are those in the MSA that were affected by the Full Optimization scenario. The Navy Baseline scenario RAF (Recruiter Assignment Factor) represents the number of recruiters stationed within that zip code. The entry in the open/close column reads "no change" when the station location remains unchanged, and it reads "open" or "close" to correspond to the station action recommended in the Full Optimization scenario. In the case of Syracuse, for example, zip codes 13045 and 13021 have two recruiters assigned and RSLES recommends they stay there. The stations in zip codes 13211 and 13126 are recommended for closure, while zip codes 13421, 13029, 13204 and 13205 are recommended for station openings with two recruiters in each station. In the final column titled "Army Collocation," a "yes" corresponds to a Navy station and an Army station being located within the same zip code in the Full Optimization Scenario. "No"

corresponds to Navy being the single service within the zip code. In this case, 18 of 33 (54.5 percetn) Navy stations are collocated with Army stations

Table 4-2. Navy Full Optimization Scenario Recommendations for NRD Buffalo

	Zip Code	Baseline Scenario RAF	Open Close	Full Optimal Scenario RAF	Army Collocation
Syracuse	13045	2	No Change	2	Yes
	13021	2	No Change	2	Yes
	13211	4	Close		No
	13126	3	Close		No
	13421		Open	2	Yes
	13036		Open	2	No
	13205		Open	2	No
Rochester	14020	2	No Change	2	Yes
	14424		Open	2	Yes
	14513		Open	2	Yes
	14456	5	No Change	2	Yes
	14615	4	Close		No
	14623	6	No Change	2	No
	14437		Open	2	Yes
	14420		Open	2	Yes
	14609		Open	2	No
Buffalo	14225	5	No Change	2	No
	14203	2	Close		No
	14075	4	No Change	3	Yes
	14094	4	No Change	2	Yes
	14150	4	No Change	2	No
	14221		Open	2	No
	14120		Open	2	No
	14304		Open	2	No
	14223		Open	2	Yes
Utica	13421		Open	2	Yes
	13440	2	Close		No
	13413	5	Close		No
	13316		Open	2	No
	13501		Open	2	Yes

	Zip Code	**Baseline** Scenario RAF	Open Close	**Full Optimal** Scenario RAF	Army Collocation
Albany	12866	2	No Change	2	Yes
	12010		Open	2	Yes
	12205	4	Close		Yes
	12305	3	Close		No
	12180	4	No Change	2	No
	12208		Open	3	No
	12309		Open	2	No
	12095		Open	2	Yes

Most of the production increase from the New Recruiter Optimization scenario (compared to the Navy Baseline scenario) is realized in the six largest MSA's from our sample, where production increases and average of 5.9 percent. Production increases between the Navy Baseline scenario and the Full Optimization scenario are the same for small-sized and medium-sized population categories at 5.5 percent

C. ARMY STATION AND RECRUITER ALIGNMENT AS COMPARED TO ATAS

To review production potential for Army recruiting we developed the same three scenarios in RSLES. Table 4-3 lists the estimated Army high-quality contract production by MSA for the "Baseline" scenario, the "New Recruiter Optimization" scenario and the RSLES "Full Optimization" scenario. The last column in the table represents the percentage change in production from the Baseline to the Full Optimization Scenario. For the 39 MSA sample, the New Recruiter Optimization scenario (column 2 in Table 4-3) increases the number of high-quality male accessions by 93 compared to USAREC decisions made using ATAS (column 1 in Table 4-3). This represents an increase in

production of 1.46 percent. If we extrapolate this percentage improvement to all MSA's in the U.S., we could expect 612 more high quality accessions per year if new stations were opened under RSLES guidance as compared to ATAS.

The Army Baseline Scenario is based on the Recruiting Battalions' actions. Each battalion makes resource allocation decisions utilizing ATAS as a planning tool in the Recruiting Market Analysis (RMA) process. Battalions within USAREC are assigned an authorization of production recruiters. This number of recruiters is inputted into ATAS where it is multiplied by a ratio of a station's three-year high-quality ASAD over the battalion's three-year high-quality ASAD contract production to obtain the number of On-Production Regular Army (OPRA) recruiters for the station.

Each Army Battalion will look for trends in market demographics and ASAD contract production versus other services production. The Army's goal is to achieve 40 percent of the DOD contracts written in a zip code. Company Commanders are given a 15 percent tolerance in historical production (from the recruiting company's average) to allow for their variation in their individual decision-making strategy.

When the Army begins to fail to produce a minimum of 25 percent of ASAD contracts then the RMA process forces them to open new stations in the affected zip codes. Prior to making final station boundary decisions in the RMA process, decision-makers must insure compliance with Army recruiting guidelines (USAREC, 1997). Each recruiter should have an inventory of 200 to 800 male seniors and have one productive high school (produces contracts and administers the High School ASVAB) in their

assigned territory. Each recruiter must have an equitable share of territory based on a three-year average of ASAD. Like the Navy's STEAM, ATAS incorporates market demographics. ATAS, with the assistance of MapInfo software, will "build station territories." Like the Navy's process, the Army decision-makers must still delineate which zip codes to assign to each station. The Army places more emphasis on high school seniors as the primary market. In addition, Army places a 100 percent weight on the ASAD share to obtain a station's OPRA. These two factors represent the differences in their approach to resource allocation as compared to the Navy and RSLES.

If the recommendations of the Full Optimization scenario are implemented, RSLES predicts an increase of 381 high quality accessions in the 39 MSA's. This represents an increase in production of 5.72 percent over the Baseline scenario (column 3 vs. column 1 in Table 4-3). This percentage increase is consistent with production gains for the Navy. Extrapolating this percentage difference to all MSA's yields 2,507 additional high-quality Army accessions per year. Increased production of this magnitude once again makes the RSLES option very attractive and could eliminate half of the Army's annual recruiting shortfalls. However, consideration must be given to the costs of wholesale station changes. Our main focus was on Navy recruiting so we did not organize and analyze data to aggregate the station opening and closing recommendations from the Army Full Optimization scenario.

We would recommend that battalions that contain an MSA listed in Table 4-3 that has at least a 10 percent increase in production from the Baseline Scenario to the Full

Optimization Scenario review the station changes listed in Appendix D. In Nashville, Tennessee, for example, 17 more high-quality male accessions per year represents a 14.8 percent increase in production. On the other hand, we recommend that the RSLES model recommendations be ignored for MSA's in Table 4-3 with less than a 2 percent increase in production. Holding all else constant, cities such as Chattanooga and Baton Rouge, for example, are already producing about the best they possibly can given their current goals and resource constraints.

RSLES station location recommendations provide the greatest impact on high quality production in the Central region. The potential 3.6 percent increase in production in the New Recruiter Optimization scenario occurs primarily in the Chicago MSA. Increases in the North and South regions were virtually negligible. The Full Optimization scenario increases production by 7.2 percent in the Central region and 6.2 in the West region. It is interesting to note the Army has recognized the potential of these regions because they established 97 of 137 (70.8 percent) of their new stations in these two regions in fiscal years 1999 and 2000. Our sample included 18 new USAREC stations, of which eight opened in the Central region and four in the West region.

In reviewing the MSA's by market size, the largest increases in production between the New Recruiter Optimization scenario and the Army Baseline scenario occur in the six largest MSA's. The production increases in the Army's Full Optimization scenario are different from those obtained in the Navy's Full Optimization scenario. For the Army the large MSA's could increase production by 7.8 percent, medium MSA's by

5.2 percent and small MSA's by 3.7 percent while the production increases in the Navy's MSA's ranged from 5.4 percent to 5.6 percent.

Table 4-3. Army High-Quality Contract Production

MSA	Baseline Scenario	Recruiter Optimization Scenario	Full Optimization Scenario	% Change Baseline to Full Optimal
Nashville	115	117	132	14.8%
Chicago	698	771	795	13.9%
Stockton	64	71	72	12.5%
Lexington	59	60	66	11.9%
Salinas	36	36	40	11.1%
Fresno	62	63	68	9.7%
Louisville	92	95	100	8.7%
Syracuse	162	163	176	8.6%
Denver	250	252	271	8.4%
Rochester	121	121	131	8.3%
Albany	113	114	121	7.1%
Las Vegas	178	178	190	6.7%
Atlanta	327	327	349	6.7%
Visalia	47	47	50	6.4%
Modesto	66	66	70	6.1%
Orlando	320	321	339	5.9%
Knoxville	87	86	92	5.7%
Milwaukee	262	262	277	5.7%
San Francisco	487	489	513	5.3%
Appleton	82	82	86	4.9%
Greenville	125	126	131	4.8%
Little Rock	154	154	161	4.5%
Oklahoma City	315	314	328	4.1%
Minneapolis	194	197	202	4.1%
Columbia	101	100	105	4.0%
Monroe	53	53	55	3.8%
Sacramento	194	197	201	3.6%
Madison	89	89	92	3.4%
Utica	62	62	64	3.2%
New Orleans	313	315	323	3.2%
Shreveport	129	129	133	3.1%
Jacksonville	202	202	206	2.0%
Charleston	111	110	112	0.9%
Melbourne	114	112	115	0.9%
Buffalo	170	169	171	0.6%
Augusta	98	98	98	0.0%
Wausau	53	53	53	0.0%
Baton Rouge	118	116	117	-0.8%
Chattanooga	59	58	58	-1.7%
Total	2324	2415	2561	10.2%

Table 4-4 displays the required station actions recommended by RSLES in the North Region. The five MSA's in which changes were made during fiscal years 1999 or 2000 are listed in column 2 of Table 4-4. The zip codes listed are those in the MSA affected by the Full Optimization scenario. The Army Baseline scenario RAF (Recruiter Assignment Factor) represents the number of recruiters stationed in each zip code. The open/close column reads "no change" when the station location remains unchanged, while the "open" or "close" label refer to the station action recommended in the Full Optimization scenario. In the case of Syracuse, for example, zip codes 13045 and 13421 have stations with two recruiters assigned to each and RSLES recommends they stay there. However, zip code 13261 keeps a station in both scenarios but the number of recruiters assigned differs. Stations in zip codes 13211 and 13126 are recommended for closure, while zip codes 13021, 13204, 13208, 13069, 13209, and 13057 are recommended for station openings with two recruiters in each station.

As mentioned previously, the potential for increased production may at first glance make the RSLES option seem attractive; however, consideration must be given to other environmental factors. In our North region sample, maximum production with the optimal station alignment for USAREC would require 13 station closures and 32 station openings. Decision-makers must determine through a cost benefit analysis if 45 station location changes are justified to obtain just 35 additional high quality accessions. RSLES generally opens two-person stations due to the low cost of this action, while the services tend to incorporate higher station manning (with the Army generally having the higher

RAF). RSLES breaks up large stations and allocates the recruiters more efficiently, subject to a budget constraint.

Table 4-4. Army Full Optimization Scenario Recommendations for North Region MSA's

	Zip Code	Baseline Scenario RAF	Open Close	Full Optimization Scenario RAF
Syracuse	13045	2	No change	2
	13261	5	No change	3
	13021		Open	2
	13211	5	Close	
	13204		Open	2
	13126	5	Close	
	13421	2	No change	2
	13208		Open	2
	13069		Open	2
	13029		Open	2
	13057		Open	2
Rochester	14020	4	No change	2
	14424	2	No change	2
	14513	3	No change	2
	14614	6	No change	2
	14456	2	No change	2
	14615	5	Close	
	14623	4	Close	
	14580		Open	2
	14606		Open	2
	14617		Open	2
	14621		Open	2
	14437		Open	2
	14103		Open	2
	14420		Open	2
Buffalo	14202	6	Close	
	14301	4	Close	
	14224	2	Close	
	14225	4	Close	
	14215		Open	3
	14075	4	No change	2
	14094	2	No change	2
	14150	4	Close	
	14043		Open	2
	14211		Open	2
	14220		Open	2

	Zip Code	Baseline Scenario RAF	Open Close	Full Optimization Scenario RAF
Buffalo (continued)	14305		Open	2
	14224		Open	2
	14207		Open	2
	14213		Open	2
	14223		Open	2
Utica	13350	2	No change	2
	13421	2	No change	2
	13440	5	Close	
	13413	4	Close	
	13407		Open	2
	13357		Open	2
	13365		Open	2
	13501		Open	2
Albany	12203	4	No change	3
	12866	3	No change	2
	12010		Open	2
	12804	5	No change	2
	12205		Open	2
	12305	4	Close	
	12180	5	Close	
	12065		Open	2
	12170		Open	2
	12095		Open	2
	12018		Open	2

D. MODEL APPLICATION CONCERNS

There are several issues that emerged after the RSLES application. One issue centered on our selections of candidate zip codes. Our decision to select candidate zip codes based on historical production was made after gathering information in interviews with NRD decision-makers from four NRD's and Navy Recruiting Command Central Region headquarters. The overwhelming majority of interviewees (13 of 17) claimed that historical production is the most important factor in determining station location actions as determined through personal interviews using Appendix B as a guideline. This

criterion was applied by CNRC, however, in only a slight majority of the MSA's in our sample. In our sample, districts actually have stations, or intend to open stations in 23 of the 39 (59 percent) zip codes with the highest DOD production history. RSLES, on the other hand, chose to locate stations in 54 percent of the highest producing zip codes. These results suggest that historical production is only one of many factors in station site selection. From our 17 structured interviews and our collective experiences as recruiting decision-makers, market demographics is the second most important factor influencing station location.

Table 4-5 is a comparison of the number of Army and Navy recruiters assigned in the Baseline scenario as compared to the New Recruiter Optimization scenario for each MSA. In the New Recruiter Optimization scenario RSLES did not assign a total of 11 available Navy recruiters and one available Army recruiter. We believe part of this variation can be explained by the proportional difference in the number of recruiters and recruiting stations added by the Navy as compared to the Army. The Navy added 145 recruiters and 53 stations in our sample MSA's whereas the Army only added 37 recruiters and 18 stations.

In Table 4-5, column 1 displays the number of Navy recruiters assigned to a specific MSA as per the NRD's decisions. Column 2 displays the number of Navy recruiters in each MSA as recommended by the New Recruiter Optimization scenario. Column 3 displays the number of Navy recruiters that were available but not assigned by

the RSLES model. Columns 4, 5 and 6 repeat columns 1, 2 and 3 but display Army recruiter numbers.

Table 4-5. Recruiters in Baseline Scenario vs. New Recruiter Optimization Scenario

MSA	# NREC Navy Baseline Scenario	# NREC New Recruiter Optimization	# NREC Not assigned	# AREC Army Baseline Scenario	# AREC New Recruiter Optimization	# AREC Not Assigned
Atlanta	41	41	0	55	55	0
Greenville	17	17	0	22	22	0
Columbia	12	12	0	21	21	0
Charleston	16	15	1	21	21	0
Augusta	8	7	1	15	15	0
Syracuse	11	11	0	19	19	0
Buffalo	19	19	0	26	26	0
Albany	13	13	0	21	21	0
Rochester	17	17	0	26	26	0
Utica	7	7	0	13	13	0
Chicago	114	113	1	126	125	1
Oklahoma City	29	28	1	34	34	0
Denver	57	56	1	45	45	0
Orlando	33	32	1	43	43	0
Jacksonville	22	22	0	30	30	0
Melbourne	9	9	0	17	17	0
Minneapolis	27	27	0	35	35	0
Milwaukee	22	22	0	23	23	0
Appleton	5	5	0	6	6	0
Madison	4	4	0	7	7	0
Wausau	2	2	0	5	5	0
Nashville	16	16	0	22	22	0
Louisville	15	15	0	26	26	0
Chattanooga	7	7	0	11	11	0
Knoxville	11	11	0	15	15	0
Lexington	9	9	0	10	10	0
New Orleans	24	23	1	35	35	0
Monroe	6	6	0	6	6	0
Shreveport	8	8	0	14	14	0
Baton Rouge	9	9	0	13	13	0
Little Rock	10	10	0	14	14	0
Las Vegas	22	21	1	24	24	0
San Francisco	73	73	0	71	71	0
Sacramento	31	30	1	33	33	0
Modesto	12	10	2	10	10	0
Stockton	12	12	0	10	10	0
Visalia	6	6	0	9	9	0
Salinas	4	4	0	6	6	0
Fresno	12	12	0	14	14	0

To determine why the New Recruiter Optimization scenario did not assign 11 Navy recruiters we must remember RSLES maximizes production subject to a budget constraint and a constraint of a minimum station size of two recruiters. In nine of the MSA's where recruiters were left unassigned RSLES did not have enough funding to buy an additional recruiter for that particular MSA scenario. However, in the case of Modesto two Navy recruiters were left unassigned. The cause of this is unknown. The Army had fewer non-assigned recruiters because USAREC opened new stations in only 17 of the 39 sample MSA's. Secondly, in three MSA's the two-person constraint for the Army was lowered to one to allow USAREC to maintain the status of existing one-person stations.

E. QUALITATIVE VALIDATION

Reliability is not an issue with RSLES because the same constraints and input data are always utilized; therefore, RSLES will output the same results every time. The primary concern is whether RSLES, in its current from, is a viable tool that can assist CNRC/USAREC, JRFC and ACOE in making station location decisions, or whether additional analytical work is required to arrive at sound location decisions. Undoubtedly, recruiting is fraught with uncertainties. Different local markets produce different amounts of contracts and the differences are often due to unmeasureable factors. The integration of an econometric model and a cost model into a predictive model such as RSLES, which explains over 90 percent of the historical data, is an excellent start for a decision making tool.

The original GAO and Congressional mandates to OSD (1996a) were twofold: 1) Conduct cost-benefit analyses in all decisions over maintaining or establishing new recruiting stations; 2) More specifically, evaluate the benefits and costs of keeping stations open in less productive areas. As a result, OSD set performance criteria for any model that would be used to determine the optimal number and geographic location of recruiting stations. Those criteria were:

1) The model must integrate effects of geographic location and station structure on station costs, contract production and station territory;
2) The model must develop empirical relationships using statistical methods and objective data;
3) The model must use principles of resource allocation efficiency that meet services' recruiting objectives with JRFC resource constraints;
4) The model must capture the institutional aspects associated with choosing the number, type and location of recruiting stations;
5) The model must build on existing literature.

RSLES can be validated on almost all of these criteria. First, RSLES integrated the effects of geographic location on station costs by developing an empirical model to estimate how much local area demographic characteristics affect station costs (Hogan, 1999). Second, an econometric model developed by Hogan et al. (1998) determined the effects of geographic location on production. The effects of geographic location on station territory were accounted for in Gue's (2000) optimization model. The RSLES

model integrates the econometric model, cost model and optimization model to provide station allocation recommendations at the MSA level.

The two-service RSLES model was built to meet Army and Navy recruiting objectives. The primary recruiting objective is to maximize the production of 17 – 21 year old, high quality, males. However, numerous constraints apply to the utilization and assignment of resources that are directly related to contract production. Although JRFC funding constraints were considered in developing the cost model, other, non-fiscal constraints are not currently included in RSLES. Constraints that are currently not programmed into RSLES include:

1) Local ACOE regulations mandating that all new stations opened in the Chicago MSA must be collocated. (RSLES could be programmed to allow for this type of local constraint.);
2) JRFC and ACOE guidelines that lease cost not exceed $35 per square foot for new station proposals (conversation by author with LCDR Schoen, CNRC Code 355, Jan 2000);
3) JRFC guidelines that stations must be located more than 50 miles away from the nearest same-service full time recruiting office, unless they are located within a metropolitan area greater than 200,000 people. In metro areas new stations may be located within 30 minutes drive from the nearest same service full time recruiting office (ACOE, 2000).

Although these constraints are not built into RSLES it must be remembered that the primary objective of this model is to identify the zip codes for locating stations that will produce the maximum number of contracts. Today's challenging recruiting environment requires "out of the box" solutions to production shortfalls. Common sense tells us the services require office space for the number of recruiters they have and will want to allocate recruiters to the optimal locations to maximize production within budget constraints. RSLES meets its primary objective if its output is utilized as one tool in the decision making process.

The institutional aspects of the recruiting services are incorporated into RSLES. ATAS and STEAM are the station location and market analysis tools currently in use by the Army and Navy Recruiting Commands. RSLES builds on these tools by incorporating the same demographic data, and implements it in the cost, econometric and optimization models. Finally, RSLES itself was designed after extensive review of previous military and civilian work conducted within the recruiting arena. We believe RSLES meets the main criteria established by OSD in 1997 and thereby can be validated for use as designed.

V. IN-DEPTH CASE ANALYSIS OF METROPOLITAN AREAS

A. INTRODUCTION

We conducted five in-depth case analyses of metropolitan areas. Our objective was to review the rationale for NRD decisions on station alignment and to compare actual choices to RSLES recommendations from the New Recruiter Optimization and Full Optimization scenarios. During this process we spoke with decision-makers from NRD Chicago, NRD Buffalo, NRD San Diego, NRD Nashville, NRD Atlanta and Navy Recruiting Central Region Command. Commanding Officers, Enlisted Programs Officers, Chief Recruiters, Facilities Coordinators and a Market Analyst all provided insight to the districts' decisions.

We focused on five MSA's of varying size and complexity. NRD Chicago was chosen as our large MSA because LT Wilkinson had the opportunity to visit the district and it was the largest MSA for which RSLES produced feasible results. Two medium-sized MSA's also were selected. Las Vegas was chosen because of the city's rapid growth rate and because LCDR Sammis visited NRD San Diego (which covers Las Vegas). Louisville was selected to be representative of the Central Region. Utica was selected to be representative of the North Region and because both authors are familiar with the area. Finally, Charleston was chosen to represent the South Region and because it included the zip code with the highest historic production in the nation. The following five sections cover the in-depth analyses of the selected MSA's.

B. CHICAGO MSA

The Chicago MSA is the third largest in the United States based on the primary recruiting market. The MSA covers 7,226 square miles from Kenosha, Wisconsin around the southern tip of Lake Michigan to Michigan City, Indiana. NRD Chicago covers all of this territory with the exception of the Wisconsin zip codes, which belong to NRD Minneapolis. At the end of fiscal year 1999, 121 Navy recruiters serviced this territory within 30 full-time recruiting stations.

The complexity of location decisions in Chicago made it an interesting analysis. Issues such as gang boundaries, crime rates, quality high schools, and direction of traffic flows were factors in the station location process for the decision-makers in NRD Chicago. Although variables such as gang boundaries and traffic problems are difficult to measure they often affect walk-in traffic at recruiting stations as well as the ability of recruiters to entice applicants to come to their office for interviews. These factors affect most large metropolitan areas, but have not been included as variables in RSLES. It should be noted that crime statistics are not available nationwide for individual zip codes. However, crime statistics are available for local neighborhoods within individual cities and could be easily incorporated into the econometric module of RSLES for those cities.

Although NRD Chicago was achieving production goals, it was affected by the plus up in recruiters and CNRC's station size constraint (greater than or equal to 2 but less than or equal to 4). A major concern for the NRD was how to effectively break up NRS South Clark with a RAF of 13.0, which was located in a Federal building just south of

downtown Chicago. Fortunately, the NRD wanted to move out of the Federal building due to accessibility problems and lack of walk-in traffic. A second NRS that exceeded the new 2-4 station size regulation was NRS Naperville, located in a western suburb of Chicago, with a RAF of 7.0.

It was proposed by the NRD that NRS South Clark's territory be cut into three new stations. NRS Downtown I would occupy zip code 60644 and have five recruiters; NRS Downtown II would open in zip code 60608 with four recruiters; and NRS Downtown III would open in zip code 60622 with four recruiters. This proposal put five recruiting stations within a 50 square mile radius in the downtown area. RSLES in the New Recruiter Optimization scenario also recommended three new stations (see Table 5-1), but all three stations were limited to two recruiters per station. RSLES chose zip codes 60622, 60625 and 60629. Zip code 60622 (due east of Bucktown Park and west of I-90) was in agreement with the Downtown III proposal except for recruiter allocation (see map 5-1). We believe this site selection was a good choice because the zip code has four high schools, a market population over 5,000 and all-service accession data (ASAD) of 11 high quality contracts per year.

Map 5-1. Downtown Chicago

The market center of zip code 60625 is approximately 1.8 miles north of the current NRS West Addison and just south of Lincolnwood (see Map 5-2). This zip code and outlying zip codes are part of NRS West Addison's assigned territory for its four recruiters. Here again, the market demographics are very positive and the All Services Accession Data is in double-digits, but the distance between stations is not ideal. The New Recruiter Optimization scenario location choice does not solve the problem of the division of the NRS South Clark territory.

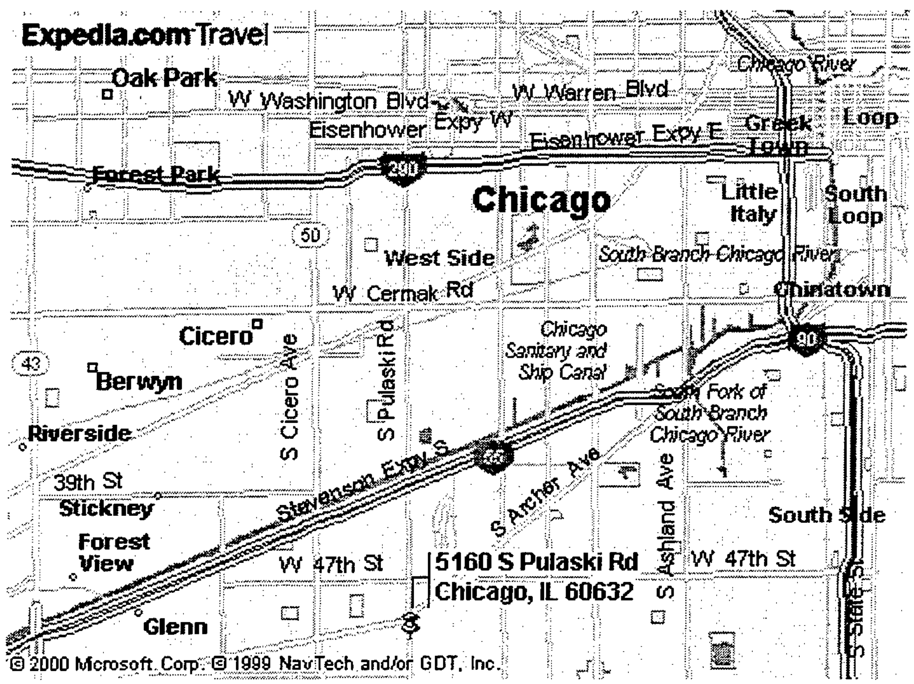
Map 5-2. North Chicago

Zip code 60629 is similar to 60625 in that it is within four miles of two existing stations and would not help solve the territory division for NRS South Clark. According to the NRD Commanding Officer opening additional stations in the downtown area was not a viable solution. The district struggled for over a year and a half to find suitable facilities for two of the three desired zip code locations for the split of NRS South Clark. The cost of property in Chicago made opening another station fiscally questionable (CDR Despain, 1999). Although funding is readily available for station openings nationwide, NRD Chicago is affected by the $35 per square foot cost constraint and its share of CNRC's facility budget.

Although the NRD proposed to open NRS Downtown II just 5.0 miles northeast of NRS Pulaski (shown on Map 5-3 as 5160 S. Pulaski), we believe zip code 60623

(Westside Chicago) would have been a more logical choice for NRS Downtown II. With almost 8,000 males in the primary market, this zip code has the largest market population in the Chicago MSA. It has three high schools and is only slightly closer at 4.0 miles north of NRS Pulaski than the NRD zip code selection (near Little Italy). In Chicago, this equates to an estimated drive time of 25-30 minutes. See Map 5-3 for a better overview.

Map 5-3. South Chicago



The New Recruiter Optimization scenario allocates the remaining seven recruiters from NRS South Clark away from downtown Chicago. The model increases the number of recruiters at NRS Bradley from four to five and recommends opening two-person stations in Lockport and Elgin, Illinois and Michigan City, Indiana. Lockport has four high schools, a market population of 3,500 and ASAD average of 16 contracts per year.

A problem faced by the NRD is that the NRS that currently covers this territory has a lease for seven recruiters through the year 2006.

Opening a station in Elgin seems to be a supportable decision. Elgin has two main zip codes and has four high schools, a market population over 5,000 and an All Service Accession Data history of 33.0 accessions per year. The question is whether NRS Carpentersville, which is 6.0 miles to the north, could survive the split. The Army is collocated in Elgin while the Navy is the only service in Carpentersville.

Michigan City is at the eastern edge of the MSA and is an inexpensive station to open. RSLES, however, does not take into account NRS Laporte which is only 9.0 miles to the southeast, but located outside the Chicago MSA. Unfortunately, boundary problems like this may arise in any populated area.

The final NRD action taken in the Downtown Chicago area was the opening of two stations. NRS South Clark officially closed in January 2000. NRS Chicago (Downtown I) opened in zip code 60651 (the next zip code west of the original choice of 60644) with five recruiters for its first full month on production (January 2000). It finished the month with seven contracts (for a production goal of six) (117 percent of mission). NRS Windy City (Downtown III) opened in zip code 60610 (the next zip code east of I-90/94 and the original choice of 60622) with six recruiters in December 1999. In two months it achieved production of 13 (with a goal of 12) (108 percent of mission). These overmanned stations were approved by CNRC because of the difficulty in finding

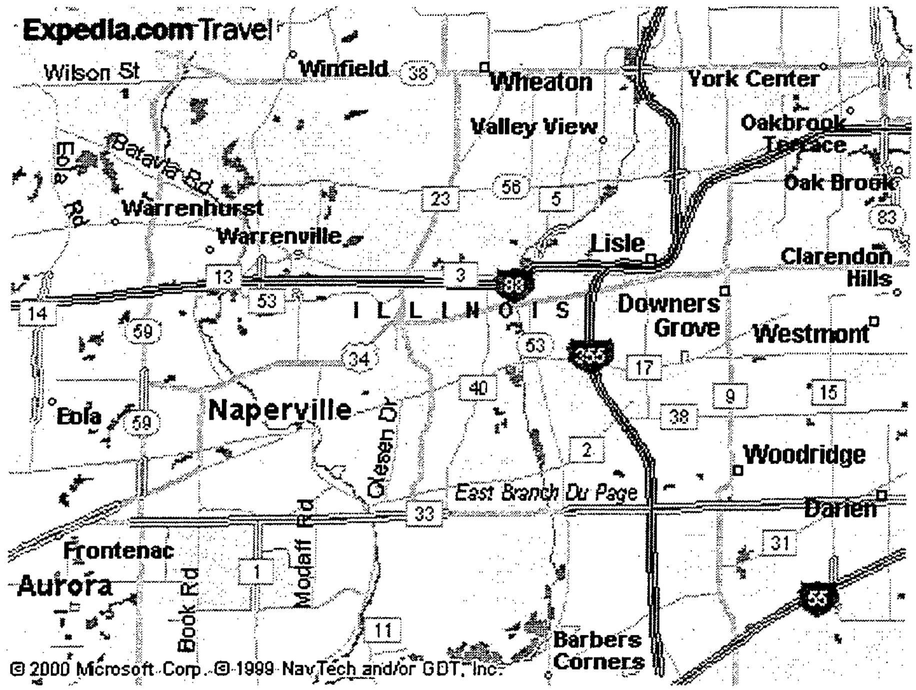
suitable locations for all services that were under the $35 per square foot lease cost constraint.

Table 5-1 shows demographics and the respective RSLES model output for zip codes selected for station assignment in at least one of the three scenarios. The ASAD historic production as well as the market population for each zip code are shown in the second and third columns. Columns 4 and 5 display the number of high schools and the collocation of the station with "A" meaning Army and "F" denoting Air Force. Column 6 is the city where the zip code is located. The remaining columns refer to RSLES output from the three scenarios. In column 7 the "New Recruiter Optimization scenario RAF" shows the location (by zip code) of stations recommended by RSLES and the Recruiting Assignment Factor (RAF) associated with each location. The "Navy Baseline RAF" column provides the same type of output in column 8 but for the Navy Baseline scenario. The open/close column compares the station action recommendations made in the Full Optimization scenario and the Navy Baseline scenario. If a station is recommended for opening in the Full Optimization scenario that does not exist in the Navy Baseline scenario the word "Open" appears in this column. If a station currently exists in the Navy Baseline scenario but is not recommended in the Full Optimization scenario the word "Close" appears in this column. In support of this comparison, The "RSLES Optimal RAF" column displays the recommended zip for locating Navy recruiting stations and the RAF assigned to that station. The last two columns show the expected average annual

lease cost of recruiting stations for each zip code selected in the Navy Baseline and Full Optimization scenarios, respectively.

In comparing the NRD's actual choices to the RSLES New Recruiter Optimization scenario for the split of NRS Naperville both decided to open stations in Aurora and Downer's Grove. RSLES recommended two-person stations and opened an additional two-person station in Wheaton. The NRD closed NRS Naperville and split the recruiters between Aurora (four) and Downer's Grove (three). The Navy was in Aurora in prior years and chose to revisit the city because of rapid population growth and Army and Air Force production success. During the first four months of fiscal year 2000 the Navy is also having production success in this area. NRS Aurora has attained 138 percent of mission by attaining 22 new contracts (against a goal of 16). With the opening of Downer's Grove the distance to Aurora increased and collocation with the three other services was achieved. The district did not choose Wheaton because of leadership, location and cost issues. NRS Naperville's best recruiter was moved to NRS Aurora to lead the four-man station there, because opening another station with two inexperienced recruiters did not make sense. No other services were located in Wheaton and the city itself had high lease costs. Wheaton's zip code already belonged to NRS Glendale Heights, which is only 4.4 miles to the north, and Downer's Grove is 8.5 miles away (refer to Map 5-4 for an overview).

Map 5-4. Naperville Split



In the three RSLES scenarios, only 65 of 354 zip codes were selected as candidate zip codes for the Chicago MSA. The complexity of this MSA may have been captured better if a larger number of candidate zip codes could have been selected. However the computational limits of the GAMS software in a PC environment prevented this. A possible consequence of our method of selecting candidate zip codes is that most of the station locations were in zip codes located near existing stations. Station locations are selected by RSLES in large part based on production history. Zip codes with less "windshield" time (distance) to the existing station generally have higher production. Therefore, the model tends to choose zip codes near existing stations. Therefore, the process of candidate zip code selection (based on production history) introduced a potential bias that may have resulted in RSLES recommendations that would have

differed if the number of candidate zip codes were larger. Secondly, in the Full Optimization scenario 52 of the 65 (80 percent) candidate zip codes were selected to open new stations. Doubling the amount of candidate zip codes would have probably given us better location spacing, but the size of the problem would have been a very difficult optimization problem for RSLES to solve. The 128 square miles in the city limits of Chicago could have been looked at separately with all 62 zip codes being selected as candidate zip codes.

The Full Optimization scenario created interesting results for the Chicago MSA. In the Baseline scenario estimated production would increase from 587 to 656 or by 10.5 percent. Additionally, this production increase could be accomplished with fewer resources. RSLES allocates only 114 of the available 121 recruiters and thus decreases resources by 5.8 percent. However, to accomplish the production increase, the Full Optimization scenario would require opening 25 new stations and closing five existing ones. A large number of recruiter transfers would be required, decreasing the manning in 26 current stations and increasing it in one. The predicted increase of annual lease costs for the recommended recruiting stations in the two scenarios would be $143,317 (see total lease cost columns in Table 5-1). The authors using NRD Chicago's average cost of $15,800 based on its latest round of station openings, estimate the one-time start-up costs of these station actions at over $443,517. The reduction of seven recruiter billets would cut recruiter costs by $79,905 and the result of realignment for CNRC would be start-up costs of $363,612. However, this analysis of costs is incomplete. A complete cost

analysis (including items such as permanent change of station costs and vehicle costs) would need to be conducted.

Table 5-1. Chicago MSA Navy Station Location/Recruiter Assignments

Zip Code	ASAD History	Mkt Pop	# HS	Other Service	Location	New Rctr Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost Full (Optimal)
46307	13.34	2642	1		Crown Pt.			Open	2		$7883
46322	9	1411	1	A	Hammond, IN	5	5		2	$6871	6871
46360	18.34	2626	4	A	Michigan City	2					
46368	18.34	2434	1		Portage			Open	2		7696
46383	23.34	5211	4	A	Valparaisao	5	5		2	4474	4474
46410	17	2252	1	A	Gary, IN	4	4		2	6783	6783
53105	7.66	1196	2	A	Burlington, WI	2	2		2	3976	3976
53142	9.33	1798	2	A	Kenosha			Open	2		3923
60014	18.67	2341	2	AF	Crystal Lake	4	4		2	7133	7133
60016	16.34	2292	0		DesPlaines			Open	2		7811
60050	14	2318	3		McHenry			Open	2		7895
60056	12.33	2471	1	AF	Mt Prospect	2	2	Close		7153	
60067	17.01	2484	2		Palatine			Open	2		8202
60073	19.66	2190	1	A	Round Lake	3	3		2	6778	6778
60085	20	4838	1	AF	Waukegan	4	4		2	6672	6672
60099	17.33	1996	1		Zion			Open	2		7664
60103	22.67	2711	1		Bartlett			Open	2		8076
60106	7.66	16.48	1		Bensenville	4	4		2	7801	7801
60110	15.67	15.95	1		Carpentersville	4	4		2	7779	7779
60115	15.66	6734	1	A	DeKalb	2	2		4	4099	4099
60120	13.34	2648	3	A	Elgin	2		Open	2		6797
60123	19.66	2413	1		Elgin			Open	2		7837
60139	9.67	1929	0	AF	Glendale Hts.	3	3	Close		7094	
60160	5	1092	1	AF	Melrose Pk	3	3		2	6707	6707
60187	14.67	4580	3		Wheaton	2		Open	2		8308
60194	14	1636	2	A	Schaumburg	4	4		2	7061	7061
60201	5	5780	1		Evanston	4	4		2	8030	8030
60411	25.67	3375	3	AF	Chicago Hts.	4	4		2	6673	6673
60426	15.34	3663	1	A	Harvey			Open	3		6504
60435	22	3173	2	A	Joliet	4	4		3	6766	6766
60441	16	3495	4		Lockport	2		Open	2		7999
60453	13.33	2241	2	AF	Oak Lawn	4	4		2	6940	6940
60462	14	2084	1		Orland Park	3	3		2	8224	8224
60473	9.33	1054	2		S. Holland	3	3	Close		7996	
60477	19.34	1751	2		Tinley Pk			Open	2		7942

Zip Code	ASAD	Mkt Pop	# HS	Other Service	Location	New Recruiter Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost (Full Optimal)
60478	6.67	1015	1	A	Country Club			Open	2		$8012
60505	19.34	3301	2		Aurora	2	4		2	$7583	7583
60506	20	2597	3	AF	Aurora			Open	2		6875
60516	8.33	1608	1	AF	Downers	2	3		2	7321	7321
60534	2.67	412	0	AF	Lyons	3	3		2	6791	6791
60608	11.34	5702	2		Chicago		4		2	7318	7318
60615	6.34	2791	3		Chicago			Open	2		7449
60617	19.33	7111	3	F	Chicago	3	3		2	6578	6578
60618	16	5107	3	A	Chicago	4	4		2	6655	6655
60620	21	6752	4	A	Chicago			Open	3		6669
60622	10.99	5580	4		Chicago	2	4		2	7390	7390
60625	13.34	5733	3		Chicago	2		Open	2		7639
60629	22.67	5336	4		Chicago	2		Open	2		7622
60632	9.67	3559	2	A	Chicago	4	4		2	6593	6593
60639	17.66	5417	3		Chicago			Open	3		7616
60641	10.68	2919	3	AF	Chicago	4	4		2	6735	6735
60644	7.67	3953	1		Chicago		5		2	7374	7374
60402	13.67	1927	1		Berwyn			Open	2		7632
60805	1.66	760	0		Evergreen Pk	5	5		2	4751	4751
60540	9.34	2455	1		Naperville			Open	2		8611
60653	5.67	2527	2		Chicago	3	3	Close		6975	
60901	15.34	1964	3	A	Kankakee			Open	6		6411
60915	6.67	769	1	F	Bradley	4	4	Close		6538	
Total						**119**	**121**		**114**	**$223612**	**$366929**

Note – highlighted area denotes zip code with highest production within the MSA

C. LAS VEGAS MSA

The Las Vegas, Nevada MSA falls within the boundary of NRD San Diego and covers 37,586 square miles over two states. This medium-size (in terms of population) MSA, found in the West Region of CNRC was originally assigned 19 recruiters in six recruiting stations. The entire Las Vegas MSA falls under one Zone, managed by an E-6 Career Recruiting Force (CRF) recruiter who has been in place for over one year. The

Zone attained 92.2 percent of goal in fiscal year 1999, whereas the District garnered over 100 percent of goal and was selected as the District of the Year for the nation.

In fiscal year 1999 three additional recruiters were added to the Las Vegas MSA. At that time, the NRD decided to open one additional three-person station and locate it northwest of Las Vegas in zip code 89131 approximately 11 miles from the heart of the city. This action was based on the potential for future population growth in the Las Vegas area. The desert environment mandates that residential growth follows water tables. Research conducted by the NRD (Beck, 2000) revealed a city government five-year plan for highway construction and water main expansion to the northwest of Las Vegas. As a result, the NRD selected zip code 89131 as the site for a new recruiting station.

This station opened in February 2000 with three recruiters assigned. As shown in Table 5-2 the ASAD historic production in zip code 89131 is 2.34 high quality male accessions per year. This is a low production average; however, this zip was chosen for its potential for future production rather than on the basis of its past performance. The highest production history for the Las Vegas MSA is in zip code 89014, which is located in Henderson, approximately 14 miles southeast of the center of Las Vegas. There is a NRS currently located in 89015, which maintains a production history of 27 high quality contracts per year. This three-person NRS covers both zip codes in the town of Henderson.

Table 5-3 shows demographics and the respective RSLES model output for zip codes selected for station assignment in at least one of the three scenarios in the Las Vegas MSA. The ASAD historic production as well as the market population for each zip code are shown in the second and third columns. Columns 4 and 5 display the number of high schools and the collocation of the station with "A" meaning Army and "F" denoting Air Force. Column 6 is the city where the zip code is located. The remaining columns refer to RSLES output from the three scenarios. In column 7 the "New Recruiter Optimization scenario RAF" shows the location (by zip code) of stations recommended by RSLES in the New Recruiter Optimization scenario and the Recruiting Assignment Factor (RAF) associated with each location. The "Navy Baseline RAF" column provides the same type of output in column 8 but for the Navy Baseline scenario. The open/close column compares the station action recommendations made in the Full Optimization scenario and the Navy Baseline scenario. If a station is recommended for opening in the Full Optimization scenario that does not exist in the Navy Baseline scenario the word "Open" appears in this column. If a station currently exists in the Navy Baseline scenario but is not recommended in the Full Optimization scenario the word "Close" appears in this column. In support of this comparison, The "RSLES Optimal RAF" column displays the recommended zip for locating Navy recruiting stations and the RAF assigned to that station. The last two columns show the expected average annual lease cost of recruiting stations for each zip code selected in the Navy Baseline and Full Optimization scenarios, respectively.

Table 5–2. Las Vegas MSA Navy Station Location/Recruiter Assignments

Zip Code	ASAD History	Mkt Pop	# HS	Other Service	Location	New Recruiter Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost (Full Optimal)
86401	22.33	1297	1		Kingman			Open	2		$3715
86403	11.67	542	1	A	LakeHavasu	2	2		2	$2951	2951
86430	1	0	1	AF	Bullhead	2	2		2	2928	2928
86442	15.67	910	0		Bullhead			Open	2		3807
89015	27	2733	1		Henderson	3	3		2	6470	6470
89030	23.67	4009	2		N. LasVegas			Open	2		3088
89102	18.01	3744	1		Las Vegas			Open	2		6407
89104	14.67	1820	2	A	Las Vegas	5	5	Close		5353	0
89107	18.68	2192	1	A	Las Vegas	4	4	Close		5564	0
89115	29.67	4031	0	A	Las Vegas	3	3	Close		5274	0
89121	22.67	3031	2		Las Vegas			Open	2		6496
89123	4.66	319	1	A	Las Vegas	2					0
89128	27.34	1363	1		Las Vegas			Open	2		6630
89131	2.34	34	0		Las Vegas		3		3	5172	5172
Total						**21**	**22**		**21**	**$33712**	**$47664**

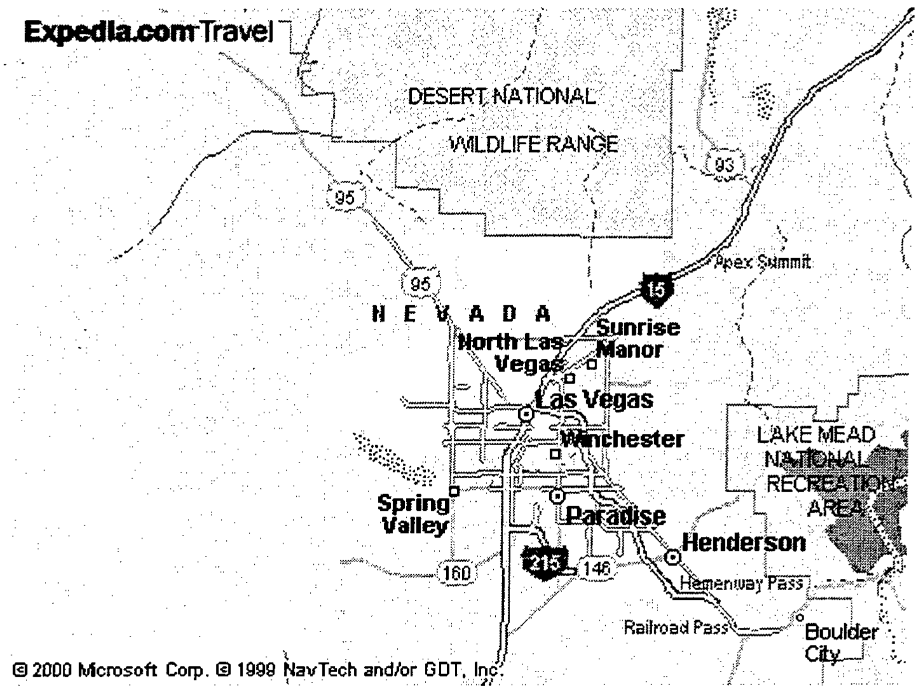
In comparing the model output from the Navy Baseline scenario to that from the New Recruiter Optimization scenario (see Table 4-1) we find the predicted production is 114 and 112, respectively. An important fact to note is the New Recruiter Optimization scenario left one of the available 22 recruiters unassigned. The reduction in production can be attributed to the decrease in the number of recruiters assigned. The amount of production lost as a result is 1.75 per cent. However, in the Full Optimization scenario, 21 recruiters were assigned with a predicted production of 120. This equates to a 7 per cent increase in production and a 4.5 percent reduction in assigned recruiters. To attain these results, seven new two-person recruiting stations would have to be opened with a

total annual lease cost estimate of $47,664 as compared to the annual lease cost of $33,712 for the Navy Baseline scenario.

The Navy-Decision and New Recruiter Optimization scenarios both yield seven recruiting stations in Las Vegas. Each scenario opens one new NRS, but the locations are different. The NRD chose to open a new station in zip code 89131 in the northwest corridor of the city whereas the New Recruiter Optimization scenario selected zip code 89123 (area around Paradise), approximately five miles south of the center of Las Vegas. (Refer to Map 5-5). As mentioned earlier, the NRD based their decisions on future growth patterns but the RSLES model does not have data on future population growth pattern.[6] Rather, RSLES determines station locations based largely on historic production and existing demographics. With low historic production, no existing high school, no other DOD recruiters in the area, and negligible market population, RSLES does not evaluate zip code 89131 as a viable option for the New Recruiter Optimization scenario. It does, however, assign a station to 89131 (with three recruiters) under the Full Optimization scenario due to the distance to other recommended stations and the market population in that area. This is in addition to four additional new Las Vegas recruiting stations and eight additional recruiters.

[6] It would be easy to obtain forecasted population by zip code. Such data are provided by various private contractors (Woods and Poole, for example) and are routinely purchased by the Recruiting Commands.

Map 5-5. Las Vegas



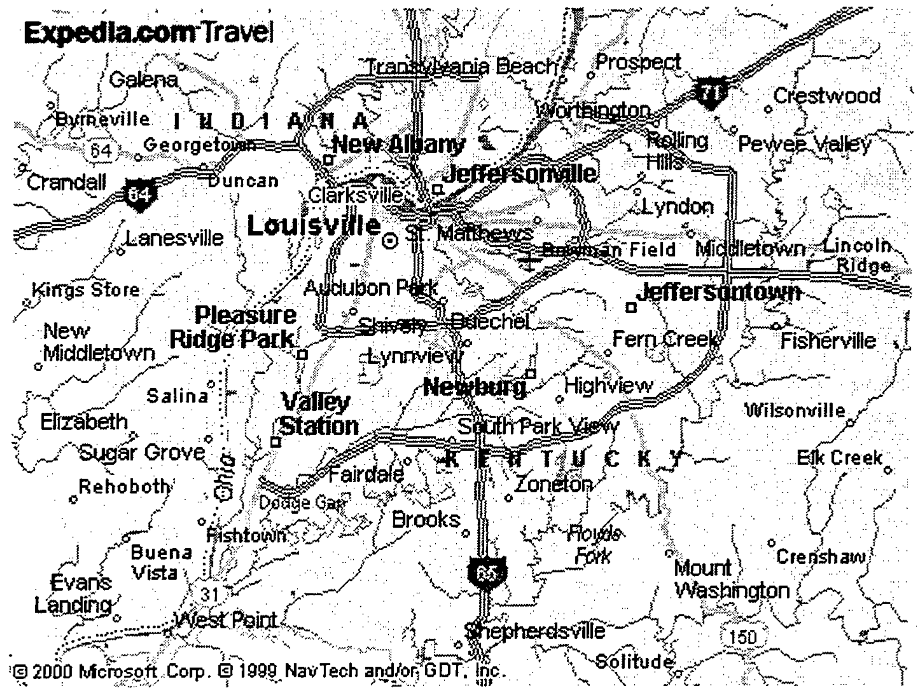
D. LOUISVILLE MSA

The Louisville, Kentucky MSA falls under the jurisdiction of NRD Nashville and covers 2726 square miles. This medium size MSA, within the South Region of CNRC, originally had 11 Navy recruiters and three Navy recruiting stations. The entire MSA falls within one Zone, which is under the leadership of an E-7 CRF. The Zone Supervisor has been in position since October 1999, but had been a ZS in another NRD. Neither the NRD nor the Zone achieved 100 percent of goal in fiscal year 1999 because the NRD had one of the lowest manning levels in CNRC.

In fiscal year 1999 four additional recruiters were allotted to the Louisville MSA. The increase of recruiters resulted in an NRD decision to open one new four-person recruiting station in zip code 40219. As shown in Table 5-3 the historic DOD production

of high-quality contracts for zip code 40219 is 18.67 per year, the highest in the MSA. Unfortunately, first quarter fiscal year 2000 ended with only 13 percent of production goal attained. Lack of training, inexperience of the assigned recruiters and personnel problems are all contributing to the slow pace of production (per phonecon LT O'Neill, 2 Feb 00). Despite current production failure, this zip code appears to have all the requirements of a good station location choice. It has two high schools, the highest market population in the MSA and the station is collocated with the Army. Neither the New Recruiter Optimization scenario nor the Full Optimization scenario selected this site for recruiting station location. An explanation for this may be that the estimated annual lease cost of a station in this zip code ($4180) is slightly higher than the average for the Louisville MSA.

Map 5-6. Louisville



In contrast to the Navy Baseline scenario, the New Recruiter Optimization scenario and the Full Optimization scenario both chose to open two, two-person stations in Crestwood, zip code 40014 and in Mount Washington, zip code 40047. Crestwood is approximately 18 miles northeast of the center of Louisville and Mount Washington is 22 miles southeast of Louisville along State Highway 60. (Refer to Map 5-6). Crestwood is collocated with the Army and has a DOD production history of 7.67 high-quality contract per year, one high school and is estimated to have the lowest cost of opening a new station of all of the zip codes in the MSA. Mount Washington has many of the same characteristics as Crestwood except that it has an ASAD production history of 6.66 contracts per year and is slightly more expensive to open a station.

Table 5-3. Louisville MSA Navy Station Location/Recruiter Assignments

Zip Code	ASAD History	Mkt Pop	# HS	Other Service	Location	New Recruiter Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost (Full Optimal)
40014	7.67	840	1	A	Crestwood	2	0	Open	2		$2489
40047	6.66	500	1		Mt. Wash	2		Open	2		2871
40202	0.66	234	2	A	Louisville	4	4		2	$3543	3543
40216	13.33	2563	3	A	Louisville	4	4	Close		4155	0
40219	18.67	2944	2	A	Louisville	0	4	Close		4208	0
47129	8.67	1435	0	A	Clarksville	3	3			4672	0
40214	18.66	2802	4		Louisville			Open	2		5060
40031	6	965	0		La Grange			Open	2		3277
40218	11.33	1962	0		Louisville			Open	2		5043
47112	6	734	1		Corydon			Open	2		5328
Total						**15**	**15**		**14**	**$16578**	**$27611**

Note- Highlighted area denotes zip code with the highest production within the MSA

Table 5-3 shows demographics and the respective RSLES Model output for zip codes in which a station was assigned in at least one of the three scenarios in the Louisville MSA. The ASAD historic production as well as the market population for each zip code are shown in the second and third columns. Columns 4 and 5 display the number of high schools and collocation of the station with "A" meaning Army and "F" denoting Air Force. Column 6 is the city where the zip code is located. The remaining columns refer to RSLES output from the three scenarios. In column 7 the "New Recruiter Optimal scenario RAF" shows the location (by zip code) of stations recommended by RSLES in the New Recruiter Optimization scenario and the Recruiting Assignment Factor (RAF) associated with each location. The "Navy Baseline RAF" column provides the same type of output in column 8 but for the Baseline scenario. The open/close column compares the station action recommendations made in the Full

Optimization scenario and the Navy Baseline scenario. If a station is recommended for opening in the Full Optimization scenario that does not exist in the Navy Baseline scenario the word "Open" appears in this column. If a station currently exists in the Navy Baseline scenario but is not recommended in the Full Optimization scenario the word "Close" appears in this column. In support of this comparison, The "Full Optimal RAF" column displays the recommended zip for locating Navy recruiting stations and the RAF assigned to that station. The last two columns show the expected average annual lease cost of recruiting stations for each zip code selected in the Navy-Decision and Full Optimization scenarios, respectively.

In comparing the model output for the Navy Baseline scenario to the New Recruiter Optimization scenario (see Table 4-1) the predicted production is 49 and 51 per year, respectively. All available recruiters were allocated in the New Recruiter Optimization scenario, which resulted in a 4.9 percent increase in production of high-quality male contracts. The Full Optimization scenario assigned 14 recruiters and predicted annual production of 53 high quality contracts. This represents a 6.7 percent reduction in recruiters and an 8.2 percent increase in production. To accomplish the increased production, RSLES recommends seven two-person recruiting stations with three closures and six new stations resulting in an annual lease cost of $27,611 as compared to the annual lease cost for the Navy Baseline scenario of $16,578.

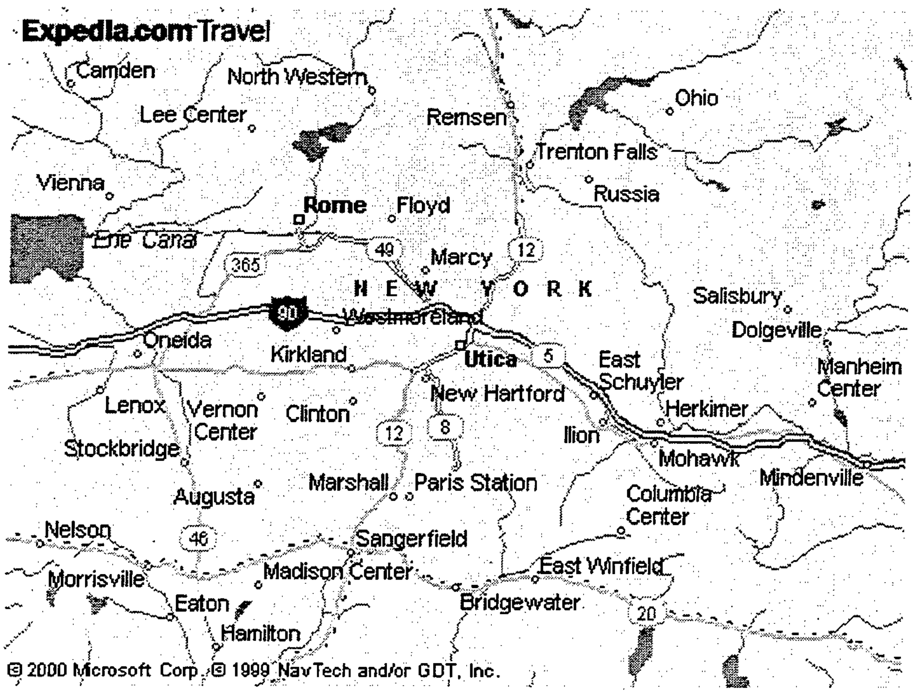
An obvious difference between the NRD decisions and RSLES recommendations is the high concentration of resources in downtown Louisville. The RAF for the inner

Louisville stations chosen by the NRD includes 12 recruiters at three stations. However, the New Recruiter Optimization scenario assigns only eight recruiters to two stations in the area and the Full Optimization scenario limits the RAF to four in two stations. A near complete revision of the station location plan is recommended in Louisville. The Full Optimization scenario suggests that three of the four existing stations be closed. A recruiter's required driving distance from his assigned station to his market area plays a large role in the RSLES model recommendations in Louisville. This is evident because the suburbs are centrally located in each station's assigned territory, thereby reducing travel costs.

E. UTICA MSA

The Utica, New York MSA is one of the smallest MSA's in the United States based on population size of the primary recruiting market. The MSA falls within the territory of NRD Buffalo. The Utica MSA lies between Syracuse and Albany and covers 3,093 square miles including Oneida and Herkimer Counties. Originally, the Utica MSA included five recruiters who experienced a change in leadership at the station and zone levels in FY 1999 and missed mission after a successful FY 1998 campaign. By the beginning of FY 2000, seven Navy recruiters serviced this territory at two full-time recruiting stations.

Map 5-7. Utica



In FY 1999, NRS Oneida (see Map 5-7) was closed because the city could not support two full-time recruiters. With CNRC's increased manning NRD Buffalo chose to open a station in Rome in zip code 13440, where historic DOD production was the highest within the Utica MSA. The three-year average of DOD high quality accessions from FY95-FY97 was 28.33 contracts. The next most productive zip code (zip code 13501) is located in Utica proper and averaged 13.33 contracts and this location was not selected for a station opening by the NRD.

Table 5-4 displays demographics and the respective RSLES model output for zip codes selected for station assignment in at least one of the three scenarios in the Utica MSA. The ASAD historic production as well as the market population for each zip code are shown in the second and third columns. Columns 4 and 5 display the number of high

schools and the collocation of the station with "A" meaning Army and "F" denoting Air Force. Column 6 is the city where the zip code is located. The remaining columns refer to RSLES output from the three scenarios. In column 7 the "New Recruiter Optimal RAF" shows the location (by zip code) of stations recommended by RSLES in the New Recruiter Optimization scenario and the Recruiting Assignment Factor (RAF) associated with each location. The "Baseline RAF" column provides the same type of output in column 8 but for the Navy Baseline scenario. The open/close compares the station action recommendations made in the Full Optimization scenario and the Navy Baseline scenario. If a station is recommended for opening in the Full Optimization scenario that does not exist in the Navy Baseline scenario the word "Open" appears in this column. If a station currently exists in the Navy Baseline scenario but is not recommended in the Full Optimization scenario the word "Close" appears in this column. In support of this comparison, The "Full Optimal RAF" column displays the recommended zip for locating Navy recruiting stations and the RAF assigned to that station. The last two columns show the expected average annual lease cost of recruiting stations for each zip code selected in the Navy-Decision and Full Optimization scenarios, respectively.

Table 5-4. Utica MSA Navy Station Location/Recruiter Assignments

Zip Code	ASAD History	Mkt Pop	# HS	Other Service	Location	New Recruiter Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost (Full Optimal)
13350	4.34	731	1	A	Herkimer	2					
13421	9.33	733	1		Oneida			Open	2		$4214
13440	28.33	2684	2	AF	Rome		2	Close		$5700	
13413	4.67	786	2	AF	New Hartford	5	5	Close		6012	
13316	6.34	371	1		Camden			Open	2		4666
13501	13.33	2472	2	F	Utica			Open	2		5465
Total						7	7		**6**	**$11712**	**$14345**

As shown in Table 5-4, the New Recruiter Optimization scenario did not choose Rome (zip code 13440) but rather selected Herkimer (zip code 13350), located in the eastern portion of the MSA, and assigned two new recruiters. Among the six larger populated areas, Herkimer has the lowest production history of the candidate zips and is 15 miles from an existing station in New Hartford. Rome is 13 miles northwest of NRS New Hartford and creates better spacing within the MSA. The nearest station (Gloversville) to the east of Herkimer is 48 miles away, but roughly two-thirds of its territory consists of a state park. RSLES does not take this distance into consideration because NRS Gloversville is outside the Utica MSA boundaries. We believe RSLES chose Herkimer because of collocation with the Army and a low annual lease cost of $2,583. To test this further we re-ran the model excluding Herkimer as a candidate zip code and RSLES chose the next town to the east (Little Falls). It also appears that travel cost was a significant factor in the Herkimer selection. In the Utica MSA approximately

half of the market population lives on a farm or in small incorporated towns, thereby increasing the weight on travel cost.

Currently, NRS Rome, zip code 13440, covers the city of Oneida and is managed by a recruiter with than less than one year of total recruiting experience. This NRS currently stands at 100 percent of its new contract objective for first quarter fiscal year 2000. In this case, the NRD's decision to open a station in Rome appears to be more likely to yield higher production than RSLES's recommendation to open one in Herkimer.

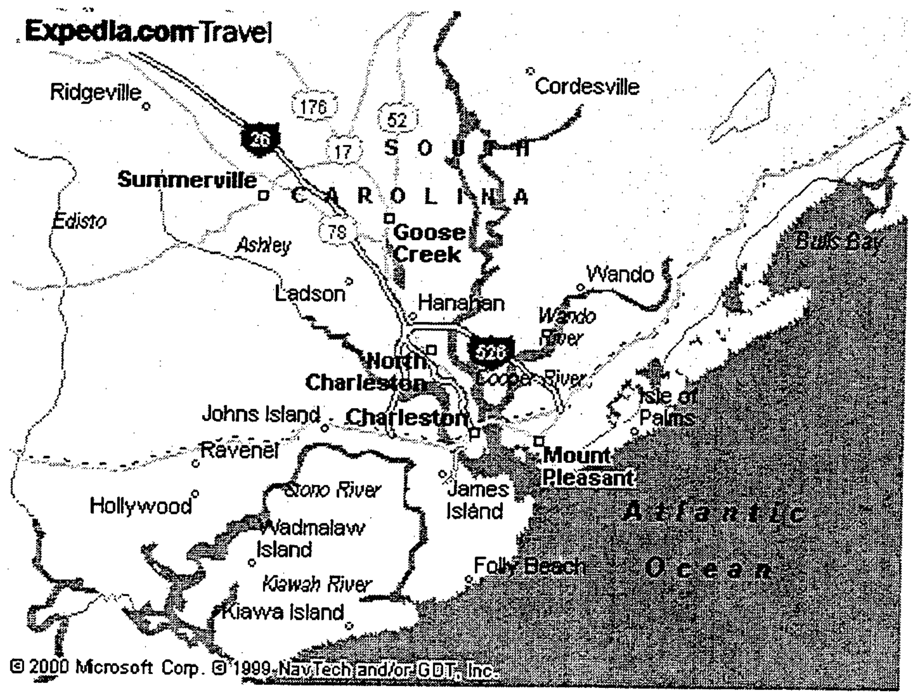
The Full Optimization scenario for Utica does not seem to produce useful results. Utica averages 35 high quality Navy accessions per year. The RSLES model predicts just 9.71 ASAD accessions in the Navy Baseline scenario and 9.97 contracts in the Full Optimization scenario. From October to January in fiscal year 2000, the Utica MSA attained 26 contracts of which 16 are high-quality males. When projected through the end of fiscal year 2000 (multiply by 3) 48 high-quality males can be expected. After subtracting an estimated DEP attrition of 15 percent, we project Utica will achieve 40 high-quality accessions for the year. The parameter estimates are suspect in this case. This reason may explain the differences in station location choices between RSLES and NRD decision-makers. The Full Optimization scenario estimates a 2.6 percent increase in production with a decrease of one recruiter. This would require opening three new stations and closing both existing stations for a total estimated annual lease cost of $14,345 as compared to a cost of $11,712 for the Navy Baseline scenario. On the other

hand, from a practical standpoint, the optimization alignment is logical for a fair market division and minimization of traveling distances.

F. CHARLESTON MSA

The Charleston, South Carolina MSA falls within NRD Atlanta and covers 2971 square miles. This small MSA, within the South Region of CNRC, originally had 10 Navy recruiters and four Navy recruiting stations. The entire MSA falls within one Zone, which is under the leadership of an E-7 member of the Career Recruiting Force (CRF). The Zone Supervisor (ZS) has been in position for approximately one year. NRD Atlanta did not meet its recruiting goal in fiscal year 1999. As a result, at the beginning of fiscal year 2000, the entire district reverted to Production per Recruiter (PPR) goaling vice the previous team incentives and award system. The effect of this change on production is unknown at this time.

Map 5-8. Charleston



In fiscal year 1999 six additional recruiters were allotted to the Charleston MSA to assist in goal attainment. The increase of six recruiters to MSA Charleston resulted in a NRD decision to open two new recruiting stations, NRS Mt. Pleasant, zip code 29464, and NRS Summerville, zip code 29483 (see Map5-8). As shown in Table 5-5 the historic production for zip code 29464 is 14.99 high-quality male accessions per year with zip code 29483 at an average of 42.67 historic accessions. The only zip code with a higher historic production average is that of Goose Creek, zip code 29445, which has an average of 51 contracts per year. We noted that this zip code was the best in the nation for high quality accessions during the 1995 through 1997 period.

Table 5-5 displays demographics and RSLES model output for zip codes selected for station assignment in at least one of the three scenarios. The ASAD historic

production as well as the market population for each zip code are shown in the second and third columns. Columns 4 and 5 display the number of high schools and the collocation of the station with "A" meaning Army and "F" denoting Air Force. Column 6 is the city where the zip code is located. The remaining columns refer to RSLES output from the three scenarios. In column 7 the "New Recruiter Optimal RAF" shows the location (by zip code) of stations recommended by RSLES in the New Recruiter Optimization scenario and the Recruiting Assignment Factor (RAF) associated with each location. The "Baseline RAF" column provides the same type of output column 8 but for the Navy Baseline scenario. The open/close column compares the station action recommendations made in the Full Optimization scenario and the Navy Baseline scenario. If a station is recommended for opening in the Full Optimization scenario that does not exist in the Navy Baseline scenario the word "Open" appears in this column. If a station currently exists in the Navy Baseline scenario but is not recommended in the Full Optimization scenario the word "Close" appears in this column. In support of this comparison, The "Full Optimal RAF" column displays the recommended zip for locating Navy recruiting stations and the RAF assigned to that station. The last two columns show the expected average annual lease cost of recruiting stations for each zip code selected in the Baseline and Full Optimization scenarios, respectively.

Table 5–5. Charleston MSA Navy Station Location/Recruiter Assignments

Zip Code	ASAD History	Mkt Pop	# HS	Other Service	Location	New Recruiter Optimal RAF	Baseline RAF	Open Close	Full Optimal RAF	Lease Cost (Baseline)	Lease Cost (Full Optimal)
29403	7.33	2193	2		Charleston	4	4		2	$5721	$5721
29405	13.33	2271	2		N. Chastn			Open	2		5712
29412	14.67	1770	1		Charleston			Open	2		6250
29418	18.33	1553	2	F	Charleston	6	6	Close		5123	
29445	51	2545	2		Goose Crk.			Open	2		6193
29461	16.67	1545	3		Moncks Crn			Open	2		4136
29464	14.99	1849	1	A	Mt Pleasant	2	2	Close		5432	
29483	42.67	2824	2	A	Summerville	3	0	Open	2		5216
29485	22.33	1508	0		Summerville		4		2	6352	6352
Total						**15**	**16**		**14**	**$22628**	**$39580**

Note – Highlighted area denotes zip code with highest historic production in the MSA

In comparing the model output for the Navy Baseline scenario to the New Recruiter Optimization scenario (see Table 4-1) we find the predicted production is 54 and 52, respectively. As seen in other scenarios, the New Recruiter Optimization scenario left one of the available 16 recruiters in Charleston unassigned. Although the reason for the decrease in production can likely be attributed to the unassigned recruiter, the amount of reduction is only 3.7 percent and Charleston is one of only three MSA's in the sample to result in reduced production (see Table 4-1). Another possible reason is that the dummy variable for the NRD that covers this MSA has a negative coefficient in the production predicted equation used by RSLES. Compared to other NRD's in the nation NRD Atlanta may have had below average production, but Charleston was the best producing MSA for its size in our sample. The Full Optimization scenario assigned only 14 recruiters but resulted in an expected production of 56 Navy accessions, showing an increase of 3.7 per cent over the Navy Baseline scenario.

The Navy Baseline scenario and the New Recruiter Optimization scenario each allow four recruiting stations (see Table 5-5) in Charleston. Each scenario opens a Navy recruiting station in Mt. Pleasant, zip code 29464 with two recruiters assigned. This zip code has one high school and is collocated with the Army. Interestingly, in the Full Optimization scenario, no station is recommended in Mt. Pleasant. Map 5-8 shows the location of Mount Pleasant, four miles east of Charleston. The Full Optimization scenario elects to have an NRS located in Charleston cover the territory previously covered by Mount Pleasant.

The second station decision made by the Navy was to open a station in Summerville, zip code 29485. The New Recruiter Optimization scenario and the Full Optimization scenario did not support this decision. They both recommended opening a station in zip 29483 in Summerville. The Enlisted Programs Officer (LT Guyer, 27 Jan 00), stated the district's preference to open a station in Summerville did not go down to the zip code level. The NRD simply requested to have a station located in the town of Summerville with the final zip code assignment being determined by the availability of commercial office space. Therefore, the difference in production history of the two zip codes did not affect the NRD's decision. An Army Recruiting Station is located in zip code 29483, which may have played an important role in the final location decision by the ACOE. In addition, the annual estimated lease cost is more expensive in zip code 29485 as compared to zip code 29483 ($6352 vs. $5216, respectively).

Fiscal year 2000 first quarter production statistics find NRS Summerville at 80 per cent of NCO year to date. Although missing goal, they are on par with the rest of the Charleston Zone, which stands at 82 percent at the end of the first quarter. It appears a relocation to zip code 29483 would increase production, but not necessarily enough to overcome the 20 percent shortfall.

The Full Optimization scenario predicts a 3.7 per cent increase in production (see Table 4-1) while supporting a 12.5 per cent decrease in recruiters (see Table 5-5). However, to attain the production increase, RSLES recommends opening five two-person stations and closing two existing stations. One of the stations opened in this model is located in Goose Creek, the zip code with the highest historical production in the MSA. NRD Atlanta decided not to open a station in Goose Creek because they believed that existing stations adequately covered the territory and they did not want to close stations. The estimated annual lease cost for the Full Optimization scenario is $39,580 as compared to the Navy Baseline scenario of $22,628 annually. To determine the complete picture of the cost and benefits of the Full Optimization scenario, the opportunity cost and the office set-up/disestablishment costs for the recommended station actions must be considered. This is an area that lends itself to further research.

VI. SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

A. INTRODUCTION

In this thesis we have analyzed the effectiveness of the RSLES Station Location Evaluation software. Our analysis applied a two-service version of RSLES to station actions proposed by the Navy and Army in 39 metropolitan areas. We looked at the actual recommended Navy and Army station actions in fiscal years 1999 and 2000 and compared them to the RSLES model in terms of estimated production, station territory alignment and recruiter assignment. Three different scenarios were analyzed. The Baseline scenario predicted production based on CNRC and USAREC proposed station alignments. The New Recruiter Optimization scenario incorporated the additional recruiters assigned to each MSA and allocated them to zip codes using the RSLES model. The Full Optimization scenario gave RSLES free reign to locate stations (and recruiters) in any of the candidate zip codes in an MSA without any constraints on prior station location or recruiter alignment. Finally, we conducted in-depth case analyses of five MSA's that are located in different geographic regions of the U.S.

Our results show that a majority of the station actions proposed by CNRC and USAREC were not in agreement with RSLES recommendations. In the 39 MSA's, only 9 of 50 (18 percent) of CNRC actions were in agreement with RSLES output and only 4 of 18 (22 percent) of USAREC actions were in agreement. The primary difference between RSLES recommendations and the service decision-maker's proposals is that

RSLES tends to concentrate recruiting stations in areas where All-Service Accession Data (ASAD) is the highest or market demographics like 17-21 year-old population and number of high schools are the best. The services, on the other hand, tended to use ASAD and variables not included in the database such as expected population growth and gang boundaries.

The Army and Navy use the RMA and STEAM processes, respectively, to make station-location recommendations and recruiter assignments. To support the RMA the Army utilizes the ATAS database while the Navy's demographic database is incorporated into the STEAM process. Both services determine the number of recruiters to assign to each zip code by weighting ASAD factors. For an Army station, OPRA is recommended based on that station's percentage of the battalion's ASAD contracts. USAREC uses the ratio of three-years of high quality ASAD contracts within that station's boundaries over a three-year total of high quality ASAD contracts within the battalion's boundaries and multiplies this ratio by the battalion recruiter authorization to obtain a station's OPRA. The Navy is a bit different in that it weights market population in its calculations of a station's RAF. CNRC Districts use different methods, but traditionally they use a 50-50 model in which male population receives a .50 weight and the ASAD share of total contracts also receives a .50 weight. The Army's On Production Regular Army authorization and the Navy's Recruiter Assignment Factor take the overall number of recruiters assigned to a battalion or district and distribute them to companies/zones and then to stations. Individual or a group of zip codes with high OPRA/RAF may then be

chosen as a new station location. Decision-makers also look to trends of historical production and whether their service is writing an equitable share of contracts out of a particular zip code or grouping of zip codes. The Army aims for a 40 percent share of ASAD contracts and the Navy aims for 28-30 percent.

Unlike CNRC or USAREC station proposals, RSLES facilitates location of stations in zip codes with the "best" demographic profiles. In addition, RSLES incorporates travel costs and estimated lease costs in the optimization process. RSLES attempts to minimize recruiter "costs" and new station lease costs by selecting zip codes that are geographically dispersed, have lower average lease costs and contain market population to support production.

The comparison of predicts production output among the three scenarios produced some surprising results. It is projected that in the New Recruiter Optimization scenario if the RSLES model had been used to open new stations instead of the actual proposals in the Baseline scenario, Navy and Army recruiting could increase production nationwide by 387 and 612 high-quality contracts, respectively. In both services' New Recruiter Optimization scenarios, RSLES recommendations are projected to increase production (two or more contracts) in 32 of the 39 MSA's.

Even more importantly, if RSLES were used to optimize all station locations nationwide, the Navy could potentially see an increase of 1,431 high quality accessions and the Army could see an increase of 2,507. However, the one-time fixed costs of making the changes recommended by RSLES are not integrated into the model. RSLES

recommends wholesale station changes that affect facility start-up costs and continuity of recruiter practices and short-term production. In our sample alone, RSLES recommended that the Navy open 229 stations and close 105 in the Full Optimization scenario.

B. AREAS FOR MODEL IMPROVEMENTS

There are a number of improvements that should be considered for incorporation into RSLES. The cost model portion of RSLES incorporates savings of $959 for a joint (two-service) station, holding size constant. In reality, the dollar savings will depend on the size of the joint station as well as the average cost of square footage for that specific location. For a larger joint station there is usually a larger common area. A larger common area in an area where real estate is more expensive will lead to fewer saving on common areas. A variable of square footage costs in each zip code multiplied by estimated common area size per recruiter would better serve the model than a blanket cost of $959.

Model output could be improved if problems identified with the data are resolved. When MSA's are defined by their assigned zip codes, small or "point" zip codes are not included. Small zip codes refer to zip codes where the market population is less than 10 and the area is less than one square mile and point zip codes refer to post office boxes or building. Although not included in the MSA's list of zip codes, these zip codes may have historical production, have less expensive office space or be in good locations for "walk-in" traffic. The RSLES database does not incorporate these zip codes because the Census Bureau does not designate them as belonging to an MSA. Further, if an attempt is made

to manually add point zip codes to the MSA's zip code list, these zip codes often have the same latitude and longitude as larger zip codes that encompass them. To solve this problem point zip codes should have their demographics added to the zip code that encompasses them. In other words, zip codes with the same latitude and longitude should have their demographics default to the zip code with the larger area. The demographics for these zip codes are generally negligible but there are instances where there is a small market population or a few ASAD contracts thereby causing model output differences.

Finally, in the validation process some bias is introduced by our selection of certain zip codes to be candidates for the New Recruiter Optimization and Full Optimization scenarios. We were unable to select all of the zip codes in a given MSA as candidates for optimization because of constraints on the optimization software. The three scenarios applied to RSLES were given candidate zip codes based on where stations were already located, or were proposed by the services. The decision of what candidate zip codes to choose and how many zip codes to select in an MSA was based on historical production patterns in the fiscal year 1995 – 1997 period. By always including the maximum number of candidate zip codes that the RSLES optimization procedure will handle, this problem will be restricted to the larger MSA's whose number of assigned zip codes exceeds RSLES' limitations.

C. CONCLUSIONS

Our applications of the RSLES model support a conclusion that RSLES provides a useful decision support tool for recruiting decision-makers. The predicted production

increases from using the RSLES model are sizeable. From a practical application sense, as former recruiting station location decision-makers, with knowledge of statistics, we believe RSLES is a useful tool. However, it must be noted there are aspects of the station location decision process that cannot be addressed via an optimization model. Leadership, recruiting expertise and future population growth patterns within MSA's are difficult concepts to measure and incorporate in any statistical model.

D. RECOMMENDATIONS

Although the model includes a wide assortment of variables, there are additional variables that could be measured and applied. The graduation rate of senior males, the influence of being in a military town and an MSA adjustment factor vice a NRD or Battalion adjustment factor would add to the model's ability to predict the production potential of a zip code. A modification that would add flexibility to the use of the model is to expand to a four-service model vice the two-service model we validated. Also, RSLES should have the capability to assign all available recruiters while considering the budget constraint. RSLES in the New Recruiter Optimization Scenario would be more effective if it included the option to allow a station to remain open but at the same time reduce or increase the number of recruiters assigned to that station (within the station size constraints established by service policy). A practical long-run problem is maintenance of the large database needed to support RSLES application. Future data warehousing may require direct connection to the STEAM/ATAS databases as well as a means to update the local (county or zip code) demographics. Lastly, and possibly most important,

is the need to make this model more user friendly. A much simpler version is needed if it will be used as a tool for use at the NRD/Battalion level by Enlisted Programs Officers or Operations Officers.

E. FURTHER RESEARCH

Time limitations restricted this study from investigating some areas that warrant further research. We examined 39 of the 256 MSA's nationwide giving us a sample size of 15.2 percent. Studies of additional MSA's would increase our confidence about the generalizability of our results. In addition a baseline scenario with no additional recruiters should be run for all MSA's to provide a starting point for the comparison of the various scenarios. Finally, a full cost benefit analysis should be conducted to study the full effects of making the wholesale station changes that are recommended in the Full Optimization scenario.

APPENDIX A. LIST OF ACRONYMS

ACOE	Army Corps of Engineers
AFQT	Armed Forces Qualification Test
ASAD	All Service Accession Data
ATAS	Automated Territory Alignment System
AVF	All Volunteer Force
CNRC	Commander Navy Recruiting Command
CRF	Career Recruiting Force
DEA	Data Envelopment Analysis
DEP	Delayed Entry Program
DOD	Department of Defense
DSS	Decision Support System
GAMS	Generalized Algebraic Modeling System
GAO	General Accounting Office
GIS	Geographic Information System
JRFC	Joint Recruiting Facility Committee
MSA	Metropolitan Statistical Area
NCO	New Contract Objective
NPS	Navy Postgraduate School
NRD	Navy Recruiting District

NRS	Navy Recruiting Station
OSD	Office of Secretary of Defense
OPRA	On Production Regular Army
RAF	Recruiter Assignment Factor
RFMIS	Recruiting Facility Management Information System
RMA	Recruit Market Analysis
RSLES	Recruit Station Location Evaluation System
STEAM	Standardized Territorial Evaluation and Analysis for Management
USAREC	U.S. Army Recruiting Command
ZS	Zone Supervisor

APPENDIX B. INTERVIEW GUIDELINE

NOTE: In regards to opening a new recruiting station answer on the importance of each factor and choose one option per factor.

1. Distance to closest recruiting station.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

2. Production history in a specific zip code.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

3. Primary market population.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

4. Territory size – Is it large enough for two recruiters?
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

5. Current advertising within zip code.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

6. Costs of new lease.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

7. Zip code area with higher rates of unemployment
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

8. The number and size of high schools near proposed station.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

9. The number and size of community colleges near proposed station.
   a. Very important
   b. Important
   c. Slightly important
   d. Not important

10. How well the primary market is identified (R'TOOLS)?
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

11. Do commuters have access to the recruiting station?
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

12. Image/Safety issues in community of proposed recruiting station.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

13. Friends of the Navy (RDAC, Navy League & VFW) or other support in zip code.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

14. Location of other service recruiters.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

15. Distance to MEPS.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

16. Station location at center of station territory.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

17. Storefront window location.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

18. Community income levels.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

19. Recruiters' travel time to their zip codes.
    a. Very important
    b. Important
    c. Slightly important
    d. Not important

20. In regards to reviewing All-Service Accession Data for historical trends, how many quarters or years is it necessary to look at?
    a. 4-6 quarters
    b. 7-11 quarters
    c. 3 years
    d. 4 years
    e. 5 years

21. Please rank 1-6 in order of importance in considering the following factors for opening/closing a recruiting station. No ties allowed.

___ Historical production (ASAD)
___ Economic conditions within zip code and outlying areas
___ Market demographics (market population, # of high schools, # of colleges, etc.)
___ Personnel situation (ROB, qualified RINCS)
___ Yearly operational costs (leases, vehicles, telephones, and postage)
___ Station image (upkeep, quality of neighborhood, accessible for walk-ins)

APPENDIX C. RSLES MODEL RESULTS

This appendix contains the results that were collected from the application of the three scenarios in RSLES.

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Table C-1 displays demographic information for each of the 39 MSA's in the sample. The Navy Recruiting District, the MSA and the Region responsible for the MSA are displayed in columns 1-3. Column 4 displays the population category (small, medium, large) of the MSA. The solution feasibility for the New Recruiter Optimization scenario is displayed in the column 5. The number of zip codes assigned to each MSA and the number of candidate zip codes identified by the authors for each MSA is found in columns 6 and 7. The FY95-97 average ASAD for the Navy and Army is displayed in columns 8 and 9 for each zip code. Column 10 displays the total ASAD for the Navy and Army.

Table C-2 displays the estimated high-quality contract production obtained from RSLES (by MSA) for the three different scenarios. Column 1 lists the MSA with Columns 2 and 3 displaying predicted production from the Navy and Army Baseline

scenarios. Column 4 shows the total production predicted for the Navy and Army combined. Columns 5-7 provide the same information but for the New Recruiter scenario while columns 8-10 display predicted production output for the Full Optimization scenario.

Table C-3 displays the aggregated total of recruiters assigned to each MSA for the Navy and Army Baseline and New Recruiter Optimization scenarios. Column 2 and 3 display the numbers of recruiters assigned for the Navy with column 4 denoting the number of recruiters not assigned by RSLES. Columns 5-7 display the same information but for the Army.

Table C-4 displays the aggregated number of recruiting stations in each MSA for the Navy and Army Baseline and New Recruiter Optimization scenarios. Column 1 displays the MSA with columns 2 and 3 showing the number of Navy recruiting stations recommended in each scenario. Columns 4 and 5 display the same data for the Army scenarios.

TABLE C-1. MSA DEMOGRAPHICS

1. NRD	2. MSA	3. CNRC Region	4. Pop Size	5. Solution Feasibility	6. MSA Zips	7. Cand Zips	8. Navy Historic Production	9. Army Historic Production	10. TOTAL
Atlanta	Atlanta	S	L	Optimal	135	35	257	301	558
	Greenville	S	M	Optimal	63	25	62	89	151
	Columbia	S	S	Optimal	32	19	56	156	212
	Charleston	S	S	Optimal	42	14	73	141	214
	Augusta	S	S	Optimal	37	13	49	106	155
Buffalo	Syracuse	N	M	Optimal	112	26	95	149	244
	Buffalo	N	M	Optimal	85	25	110	188	298
	Albany	N	M	Optimal	137	25	99	130	229
	Rochester	N	M	Optimal	123	32	107	185	292
	Utica	N	S	Optimal	63	26	35	76	111
Chicago	Chicago	C	L	Sat Tolerance	354	65	571	688	1259
Dallas	Oklahoma City	C	M	Optimal	95	24	135	246	381
Denver	Denver	W	L	Optimal	129	30	274	250	524
Jacksonville	Orlando	S	M	Optimal	92	30	177	303	480
	Jacksonville	S	M	Optimal	52	25	134	210	344
	Melbourne	S	S	Optimal	29	19	69	138	207
Minneapolis	Minneapolis	C	L	Optimal	215	50	196	194	390
	Milwaukee	C	M	Optimal	96	31	83	136	219
	Appleton	C	S	Optimal	36	9	27	36	63
	Madison	C	S	Optimal	45	21	20	29	49
	Wausau	C	S	Optimal	22	22	20	20	40
Nashville	Nashville	S	M	Optimal	104	25	95	118	213
	Louisville	S	M	Optimal	83	26	89	120	209
	Chattanooga	S	S	Optimal	44	23	45	67	112
	Knoxville	S	S	Optimal	66	24	45	62	107
	Lexington	S	S	Optimal	36	18	42	55	97
New Orleans	New Orleans	S	M	Optimal	77	30	141	153	294
	Monroe	S	S	Optimal	13	13	17	44	61
	Shreveport	S	S	Optimal	42	19	50	66	116
	Baton Rouge	S	S	Optimal	37	21	58	66	124
	Little Rock	S	S	Optimal	52	24	51	81	132
San Diego	Las Vegas	W	M	Optimal	51	25	124	221	345

1. NRD	2. MSA	3. CNRC Region	4. Pop Size	5. Solution Feasibility	6. MSA Zips	7. Cand Zips	8. Navy Historic Production	9. Army Historic Production	10. TOTAL
San Francisco	San Francisco	W	L	Optimal	290	62	481	510	991
	Sacramento	W	L	Optimal	119	30	179	271	450
	Modesto	W	S	Optimal	26	26	53	100	153
	Stockton	W	S	Optimal	29	29	63	93	156
	Visalia	W	S	Optimal	34	34	41	62	103
	Salinas	W	S	Optimal	28	28	33	43	76
	Fresno	W	S	Optimal	64	24	72	82	154

CNRC Region S = South Recruiting Region (as determined by CNRC FY00 boundries)
CNRC Region N = North Recruiting Region
CNRC Region C = Central Recruiting Region
CNRC Region W = West Recruiting Region

Pop Size < 50K = S
Pop Size 50 - 100K = M
Pop Size > 100K = L

Optimal = RSLES reached full optimization solution
Sat Tolerance = Satisfied RSLES tolerances (within 2% of optimal solution)

Navy, Army Historic Production = Average annual high-quality contracts for FY95 - FY97

TABLE C-2. PREDICTED PRODUCTION FROM THREE SCENARIOS

1. MSA	2. Navy Baseline	3. Army Baseline	4. Total	5. Navy New Recruiter Optimal	6. Army New Recruiter Optimal	7. Total	8. Navy Full Optimal	9. Army Full Optimal	10. Total
Atlanta	189	327	516	189	327	516	203	349	552
Greenville	57	125	182	57	126	183	61	131	192
Columbia	49	101	150	49	100	149	51	105	156
Charleston	54	111	165	52	110	162	56	112	168
Augusta	40	98	138	39	98	137	42	98	140
Syracuse	52	162	214	52	163	215	59	176	235
Buffalo	83	170	253	83	169	252	84	171	255
Albany	25	113	138	25	114	139	29	121	150
Rochester	37	121	158	37	121	158	46	131	177
Utica	10	62	72	10	62	72	10	64	74
Chicago	587	698	1285	646	771	1417	656	795	1451
Oklahoma City	211	315	526	208	314	522	215	328	543
Denver	217	250	467	215	252	467	224	271	495
Orlando	157	320	477	158	321	479	162	339	501
Jacksonville	100	202	302	100	202	302	105	206	311
Melbourne	53	114	167	51	112	163	52	115	167
Minneapolis	92	194	286	93	197	290	103	202	305
Milwaukee	128	262	390	129	262	391	135	277	412
Appleton	33	82	115	33	82	115	34	86	120
Madison	29	89	118	29	89	118	31	92	123
Wausau	18	53	71	18	53	71	18	53	71
Nashville	53	115	168	55	117	172	62	132	194
Louisville	49	92	141	51	95	146	53	100	153
Chattanooga	27	59	86	27	58	85	30	58	88
Knoxville	37	87	124	37	86	123	42	92	134
Lexington	34	59	93	34	60	94	38	66	104
New Orleans	173	313	486	174	315	489	180	323	503
Monroe	32	53	85	32	53	85	34	55	89
Shreveport	63	129	192	63	129	192	66	133	199
Baton Rouge	63	118	181	64	116	180	66	117	183
Little Rock	79	154	233	79	154	233	83	161	244
Las Vegas	114	178	292	112	178	290	120	190	310
San Francisco	385	487	872	377	489	866	379	513	892
Sacramento	124	194	318	125	197	322	127	201	328
Modesto	46	66	112	46	66	112	49	70	119
Stockton	45	64	109	52	71	123	51	72	123
Visalia	30	47	77	30	47	77	32	50	82
Salinas	19	36	55	20	36	56	23	40	63
Fresno	50	62	112	52	63	115	51	68	119

TABLE C-3. RECRUITER ALLOCATION FOR BASELINE AND NEW RECRUITER OPTIMIZATION SCENARIOS

1. MSA	2. Navy Baseline	3. Navy New Recruiter Optimal	4. # NREC Not assigned	5. Army Baseline	6. Army New Recruiter Optimal	7. #AREC Not assigned
Atlanta	41	41	0	55	55	0
Greenville	17	17	0	22	22	0
Columbia	12	12	0	21	21	0
Charleston	16	15	1	21	21	0
Augusta	8	7	1	15	15	0
Syracuse	11	11	0	19	19	0
Buffalo	19	19	0	26	26	0
Albany	13	13	0	21	21	0
Rochester	17	17	0	26	26	0
Utica	7	7	0	13	13	0
Chicago	121	119	2	126	125	1
Oklahoma City	29	28	1	34	34	0
Denver	57	56	1	45	45	0
Orlando	33	32	1	43	43	0
Jacksonville	22	22	0	30	30	0
Melbourne	9	9	0	17	17	0
Minneapolis	27	27	0	35	35	0
Milwaukee	22	22	0	23	23	0
Appleton	5	5	0	6	6	0
Madison	4	4	0	7	7	0
Wausau	2	2	0	5	5	0
Nashville	16	16	0	22	22	0
Louisville	15	15	0	22	22	0
Chattanooga	7	7	0	11	11	0
Knoxville	11	11	0	15	15	0
Lexington	9	9	0	10	10	0
New Orleans	24	23	1	35	35	0
Monroe	6	6	0	6	6	0
Shreveport	8	8	0	14	14	0
Baton Rouge	9	9	0	13	13	0
Little Rock	10	10	0	14	14	0
Las Vegas	22	21	1	24	24	0
San Francisco	73	73	0	71	71	0
Sacramento	31	30	1	33	33	0
Modesto	12	10	2	10	10	0
Stockton	12	12	0	10	10	0
Visalia	6	6	0	9	9	0
Salinas	4	4	0	6	6	0
Fresno	12	12	0	14	14	0

TABLE C-4. STATION ALIGNMENT FOR BASELINE AND NEW RECRUITER OPTIMIZATION SCENARIOS

1. MSA	2. Navy Baseline	3. Navy New Recruiter Optimal	4. Army Baseline	5. Army New Recruiter Optimal
Atlanta	14	14	17	16
Greenville	5	5	7	7
Columbia	4	4	4	4
Charleston	4	4	4	4
Augusta	2	2	3	3
Syracuse	4	4	5	5
Buffalo	5	5	7	7
Albany	4	4	5	5
Rochester	4	4	7	7
Utica	2	2	4	4
Chicago	33	37	33	32
Oklahoma City	8	8	7	7
Denver	11	12	12	12
Orlando	9	9	9	9
Jacksonville	6	6	6	6
Melbourne	4	3	3	3
Minneapolis	9	9	12	12
Milwaukee	6	6	8	8
Appleton	2	2	2	2
Madison	1	1	2	2
Wausau	1	1	2	2
Nashville	5	5	6	6
Louisville	4	5	7	7
Chattanooga	2	2	3	3
Knoxville	3	3	4	4
Lexington	3	3	3	3
New Orleans	7	8	9	9
Monroe	2	2	1	1
Shreveport	3	3	3	3
Baton Rouge	3	3	3	3
Little Rock	3	3	5	5
Las Vegas	7	7	6	6
San Francisco	21	22	25	26
Sacramento	8	10	10	10
Modesto	3	3	3	3
Stockton	3	3	3	3
Visalia	2	2	3	3
Salinas	1	1	2	2
Fresno	3	4	4	4

APPENDIX D. MODEL OUTPUT FOR STATION LOCATION SCENARIOS FOR EACH MSA

A. TABLE DESCRIPTION

The Tables in Appendix D show the resource allocation actions for all affected zip codes in the 39 MSA sample. Column 1 displays the NRD that the MSA's belong to as well as the individual MSA's. Column 2 shows all the affected zip codes from the three scenarios. Column 3 displays the average ASAD contracts within a specific zip code for FY95-FY97. Columns 4 and 5 represent the Army and Navy New Recruiter Optimization scenario RAF's respectively. Column 6 shows agreement or disagreement between the service Baseline RAF's and the service New Recruiter Optimization RAF's. Columns 7 and 8 represent the Army and Navy Baseline scenario RAF's respectively. Column 9 depicts whether a Navy station should open, close or have the status remain the same within that particular zip code in the Full Optimization scenario as compared to the Baseline scenario. Column 10 displays the Navy Full Optimization scenario RAF.

1. NRD Buffalo MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open Close	10. Navy Full Optimal RAF
Syracuse	13045	1.99	2	0	D	2	2		2
	13261		5	0		5	0		
	13021		0	2		0	2		2
	13211		5	4		5	4	Close	
	13032	6.01	0	2	D	0	0		
	13126	33.67	5	3		5	3	Close	
	13421	9.33	2	0	A	2	0	Open	2
	13036							Open	2
	13205							Open	2
Rochester	14020	12.99	4	2	A	4	2		2
	14424		2	0		2	0	Open	2
	14513		3	0		3	0	Open	2
	14614		6	0		6	0		
	14456		2	5		2	5		2
	14615		5	4		5	4	Close	
	14623		4	6		4	6		2
	14437							Open	2
	14420							Open	2
	14609	17.33						Open	2
Buffalo	14202		6	2	D	6	0		
	14301		4	0		4	0		
	14224		2	0		2	0		
	14225		4	5		4	5		2
	14203	0.99			D	0	2	Close	
	14075	24	4	4		4	4		3
	14094		2	4		2	4		2
	14150		4	4		4	4		2
	14221							Open	2
	14120							Open	2
	14304							Open	2
	14223							Open	2

1. MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Utica	13350	4.34	2	2	D	2	0		
	13421	9.33	2	0	A	2	0	Open	2
	13440	28.33	5	0	D	5	2	Close	
	13413		4	5		4	5	Close	
	13316							Open	2
	13501							Open	2
Albany	12203		4	0		4	0		
	12866	14.34	3	0	D	3	2		2
	12010	9.34	0	2	D	0	0	Open	2
	12804		5	0		5	0		
	12205		0	4		0	4	Close	
	12305		4	3		4	3	Close	
	12180	21	5	4		5	4		2
	12208							Open	3
	12309							Open	2
	12095							Open	2

1. MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Denver	80301	5.67	2	2	D	2	0	Open	2
	80030		5	0		5	0	Open	2
	80206		5	0		5	0	Open	2
	80010		5	0		5	0	Open	2
	80401	11.33	3	0	D	3	4	Close	
	80215		5	0		5	0	Open	2
	80104		2	0		2	0	Open	2
	80126		4	0		4	0	Open	2
	80134	13	2	0	D			Open	2
	80501	18.66	0	5	D	2	5		2
	80631		4	4		4	4		3
	80229		4	7		4	7		2
	80003	38.33	0	4		0	4		2
	80015		4	5		4	5		2
	80231		0	4		0	4	Close	
	80226		0	7		0	7		2
	80123		0	7		0	7	Close	
	80601	12.67	0	2	D				2
	80221	23.33	0	2	D				
	80033	7.67			D	0	3		2
	80012		0	7		0	7		2
	80221							Open	2
	80233							Open	2
	80020							Open	2
	80011							Open	2
	80013							Open	2
	80228							Open	2
	80120							Open	2
	80127							Open	2

1. NRD Atlanta MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Atlanta	30308	2.33	2	2	D	2	0	Open	3
	30035		5	0		5	0		
	30350	7.34	2	2	D	2	0	Open	2
	30117		2	0		2	0	Open	2
	30135		3	0		3	0		
	30269	14.01	2	0	D	2	2		2
	30281		2	0		2	0	Open	2
	30349		4	3		4	3		2
	30331		4	3		4	3	Close	
	30034		0	4		0	4		2
	30083		5	3		5	3	Close	
	30084		0	2		0	2		2
	30080		6	2		6	2		2
	30144		6	5		6	5	Close	
	30120		2	2		2	2		2
	30161		0	2		0	2	Close	
	30223		3	3		3	3		2
	30236	32.67	5	4		5	4		2
	30263		2	4		2	4		2
	30075	11.67	0	0	D	0	2		2
	30032							Open	2
	30058							Open	2
	30132							Open	2
	30062							Open	2
	30214							Open	2
	30253							Open	2
Columbia	29045	12.67	4	0		4	0	0	2
	29206		7	0		7	0		
	29212		4	3	D	4	0		
	29223	46.01	0	4		0	4	Close	
	29071	0.33			D	0	3	Close	
	29201		6	5		6	5	Close	
	29016							Open	2
	29070							Open	2
	29073							Open	2
	29025							Open	2

1. NRD Atlanta MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Charleston	29406		8	0		8	0		
	29483	42.67	6	3	D/A	6	4		2
	29407		5	0		5	0		
	29464	14.99	2	2	A	2	2	Close	
	29403		0	4		0	4		2
	29485	22.33			D	0	0	Open	2
	29418		0	6		0	6	Close	
	29445	51						Open	2
	29461							Open	2
	29405							Open	2
	29412							Open	2
Greenville	29631	3.66	3	2	D	3	0		
	29621		4	0		4	0		
	29640	6	2	0	D	2	2		2
	29681		2	0		2	0		
	29379	8.99	2	0	D	2	2	Close	
	29615		6	4		6	4	Close	
	29340	7	0	2	D			Open	2
	29301		3	5		3	5	Close	
	29625	13.66	0	4		0	4	Close	
	29627							Open	2
	29642							Open	2
	29607							Open	2
	29651							Open	2
	29349							Open	2
	29710							Open	2
Augusta	30907		4	0		4	0		
	29801		5	0		5	0	Open	2
	30809	9.34	0	2	D/A	0	3	Close	
	30906	41.67	6	5		6	5	Close	
	30904							Open	2
	29830							Open	2
	30824							Open	2

1. NRD Dallas MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Oklahoma	73034	11.33	0	0	D		2		2
City	73072		6	0		6	0	Open	2
	73110	32.66	6	2	D	6	0		
	73132	13.66	4	2	D	4	0		
	73069		0	4		0	4		2
	73114		5	4		5	4	Close	
	73115		0	4		0	4		2
	73139		5	4		5	4		2
	74074		4	4		4	4		2
	73099	28.33			D	0	3	Close	
	74801		4	4		4	4		2
	73044							Open	2
	73107							Open	2
	73119							Open	2
	73130							Open	2
	73160							Open	2
	74820							Open	2

1. NRD Minneapolis MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Minneapolis	55033	7	2	2	D			Open	2
	55082		2	0		2	0	Open	2
	55008		2	0		2	0	Open	2
	55401		3	0		3	0	Open	3
	55337	13.67	4	3		4	3		2
	55118		2	2		2	2	Close	
	55109		3	3		3	3	Close	
	55113		3	3		3	3	Close	
	55428		4	4		4	4		2
	55433		4	4		4	4	Close	
	55343		3	3		3	3	Close	
	55408	4.01			D	2	2	Close	
	55431		3	3		3	3	Close	
	55057							Open	2
	55068							Open	2
	55025							Open	2
	55313							Open	2
	55330							Open	2
	55434							Open	2
	55345							Open	2
Appleton	54901	18	2	2	A	2	2		2
	54952		4	3		4	3	Close	
	54130							Open	3
Madison	53715	2.33	2	0	A	2	0		
	53704	8.67	5	4		5	4		2
	53703							Open	2

1. NRD Minneapolis MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Milwaukee	53186	13.67	3	0		3	0		
	53204	7	2	3	D			Open	2
	53406		2	0		2	0		
	53214	13	4	0	D	4	3	Close	
	53095		2	3		2	3		2
	53105		2	0		2	0	Open	2
	53045		0	4		0	4	Close	
	53220		3	4		3	4	Close	
	53216		5	4		5	4	Close	
	53211	6			D	2	0	Open	2
	53405		0	4		0	4	Close	
	53154							Open	2
	53066							Open	2
	53223							Open	2
	53403							Open	2
	53207							Open	2
	53227							Open	2
Wausau	54449	9.99	0	0	D	2	0		
	54479	0.67	2	0	D				
	54401		3	2		3	2		2

1. NRD Jacksonville MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Jacksonville	32266	4.33	4	2	A	4	2	Close	
	32208		5	5		5	5	Close	
	32073	42.01	5	3		5	3	Close	
	32207		6	5		6	5		3
	32210		7	4		7	4	Close	
	32095		3	3		3	3		2
	32137							Open	2
	32034							Open	2
	32209							Open	2
	32043							Open	2
	32068							Open	2
	32250							Open	2
	32084							Open	2
	32086							Open	2
Orlando	32707	25.66	5	2	D	5	0	Open	2
	32839		4	0		4	0	Open	2
	32808		4	0		4	0		
	32720		5	3		5	3		2
	32714		4	4		4	4		2
	32773		3	4		3	4		2
	32803		7	4		7	4	Close	
	32809		0	4		0	4		2
	32817	21.33			D	0	3		2
	32807	15.01	0	3	A	0	3	Close	
	34744		5	4		5	4	Close	
	34748		6	4		6	4		2
	32712							Open	2
	32792	27						Open	2
	32812							Open	2
	32824							Open	2
	34769							Open	2
	32726							Open	2
	32771							Open	2

1. NRD Jacksonville MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Melbourne	32940	6.33	4	4	D	4	0	Open	2
	32955		8	2		8	2	Close	
	32780	21.33			D	0	2		2
	32935	45.01			D	0	2		2
	32904		5	3		5	3	Close	
	32901							Open	2

1. NRD San Francisco MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Sacramento	95603		0	0				Open	2
	95713		3	0		3	0	Open	2
	95945	7	0	2	A		4		2
	95667	20	2	2	D	2	0	Open	4
	95825	10	4	2	D	4	0		
	95616	12.99	0	2	D			Open	2
	95833	12.67			D	0	4	Close	
	95758	14.66			D	0	3	Close	
	95624		2	0		2	0		
	95632	10	0	2	D			Open	2
	95660		3	0		3	0		
	95823	29.22	5	4		5	4		2
	95670		4	4		4	4	Close	
	95661		4	4		4	4	Close	
	95628		4	4		4	4	Close	
	95695		2	4		2	4		2
	95822							Open	2
	95826							Open	2
	95682							Open	2
	95842							Open	2
	94558							Open	2

1. NRD San Francisco MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Stockton	95237	1.33	2	4	D	2	0	Open	2
	95336	29.34	4	4		4	4		2
	95240	15			D	0	4	Close	
	95207		4	4		4	4		2
	95690							Open	2
	95376							Open	2
Visalia	93257	29.34	2	2	A	2	2		2
	93277		4	4		4	4	Close	
	93555	30.33	3	0		3	0	Open	2
	93274							Open	2
Salinas	93927	4.01	2	0	D				
	93955	10.33			D	2	0		
	93906	16.33	4	4		4	4	Close	
	93930							Open	2
	93012							Open	2
Fresno	93601		3	0		3	0		
	93654	8.01	2	2	D				
	93706	7.33			D	0	4	Close	
	93662	5.99	0	2	D	2			
	93612		5	4		5	4	Close	
	93705		4	4		4	4	Close	
	93631							Open	2
	93637							Open	2
	93638	20.66						Open	2
	93644							Open	2
	93657							Open	2
Modesto	95380	22	2	0	D	2	4		3
	95023	11.99	0	2	D			Open	2
	95350		5	4		5	4	Close	
	94550	30.33	3	4		3	4	Close	
	95355							Open	2
	95367							Open	2
	95363							Open	2

1. NRD San Francisco MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
San Francisco	94952	8.33	3	2	D	3	0	Open	2
	94599	0.67	2	0		2	2		2
	94014		2	0		2	0		
	94127		1	0		1	0	Open	2
	95688		3	0		3	0		
	95616	12.99	1	2	D			Open	2
	94403		3	0		3	0		
	94102		3	0		3	0	Open	2
	94112	13.67	0	2	D				
	94086	13.67	3	0	D	3	3	Close	
	95687	47			D		3	Close	
	94605	6.67			D		2		2
	95111	1.12			D	2		Open	2
	94015		0	4		0	4	Close	
	95122	14.01	1	2	D			Open	2
	94611		2	0		2	0	Open	2
	94801		2	0		2	0	Open	2
	94533	53.33	4	4		4	4		2
	95401		4	4		4	4		2
	94002		0	3		0	3		2
	94590		3	4		3	4		2
	95117		4	4		4	4		2
	94111		0	4		0	4		2
	94501		2	3		2	3		2
	94509		3	4		3	4		2
	94550		3	4		3	4		2
	94538		3	4		3	4		2
	94523		3	4		3	4	Close	
	94545		4	4		4	4	Close	
	94806		0	3		0	3	Close	
	95116		4	4		4	4	Close	
	95118		4	4		4	4	Close	
	95010		2	2		2	2		2
	95020	11.66	2	2	D	2	0	Open	2
	94928							Open	2
	94559							Open	2

1. NRD San Francisco MSA	2. • Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
San Francisco (continued)	94544							Open	2
	95023							Open	2
	95123							Open	2
	95136							Open	2
	95076							Open	2
	95051							Open	2
	94080							Open	2
	94521							Open	2

1. NRD San Diego MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Las Vegas	89115	29.67	5	3		5	3	Close	
	89123	4.66	6	2	D	6	0		
	89131	2.34			D		3		3
	86430		2	2		2	2		2
	89015		0	3		0	3		2
	86403		2	2		2	2		2
	89107		5	4		5	4	Close	
	89104		4	5		4	5	Close	
	86442							Open	2
	86401							Open	2
	89030							Open	2
	89102							Open	2
	89121							Open	2
	89128							Open	2

1. NRD Nashville MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Louisville	40014	7.67	2	2	D	2	0	Open	2
	40047	6.66	2	0	D			Open	2
	40219	18.67	4	0	D	4	4		2
	40220		4	0		4	0		
	47129		4	0		4	0		
	40216		4	4		4	4	Close	
	47170	6.34			D	2	0		
	40202		2	4		2	4		2
	47130		0	3		0	3	Close	
	40214							Open	2
	40031							Open	2
	40218							Open	2
	47112							Open	2
Nashville	37129	19.33	3	0		3	0		
	37087		2	0		2	0		
	37221	4.33	3	4	A	3	4	Close	
	37130		0	3		0	3		2
	37066		2	2		2	2		2
	37013		6	3		6	3	Close	
	37043		6	4		6	4	Close	
	37086							Open	2
	37122							Open	2
	37207							Open	2
	37055							Open	2
	37064							Open	2
	37160							Open	2

1. NRD Nashville MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Knoxville	37919		4	0		4	0	Open	3
	37917	8.34	4	3	D	4	0		
	37804		2	0		2	0		
	37701	2.67			D	0	3	Close	
	37922		0	5		0	5	Close	
	37830	15.34	5	3		5	3	Close	
	37771							Open	2
	37920							Open	2
	37931							Open	2
	37862							Open	2
Lexington	40391	17.32	2	0	D	2	2	Close	
	40503	9.33	0	2	D			Open	3
	40509		5	5		5	5	Close	
	40475	22.34	3	2		3	2		2
	40324							Open	2
	40361							Open	2
Chattanooga	37411		5	0		5	0	Open	3
	30742		3	0		3	0		
	37415	9.66	3	2	D	3	0		
	37343	17.34			D	0	2	Close	
	37421		0	5		0	5	Close	
	37341							Open	2
	30707							Open	2

1. NRD New Orleans MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
New Orleans	70433	9.67	3	2	D	3	0		
	70058	29.01	0	0	D	0	4		2
	70068	12.67	2	0	A	2	0	Open	2
	70448	10.34	0	2	D			Open	2
	70072		4	0		4	0	Open	2
	70115	9.66	0	2	D			Open	2
	70127	14.34	4	0	D	4	3	Close	
	70458		4	4		4	4	Close	
	70043		2	3		2	3		2
	70053		5	3		5	3	Close	
	70119		4	3		4	3		2
	70003		7	4		7	4	Close	
	70438							Open	2
	70460							Open	2
	70047							Open	2
	70063							Open	2
Shreveport	71037	11.66	3	2	D			Open	2
	71111	14	4	3		4	3	Close	
	71104	6.33			D	0	2	Close	
	71107	11			D	3	0		
	71118		7	3		7	3	Close	
	71055							Open	2
	71082							Open	2
Baton Rouge	70806		6	0		6	0		
	70785	9	2	3	D				
	70805		5	0		5	0		
	70815		0	3		0	3	Close	
	70809	4.34			D	0	3	Close	
	70820	6.33			D	2	0		
	70714		0	3		0	3	Close	
	70422							Open	2
	70808							Open	3
	70726	19.34						Open	2
	70818							Open	2

1. NRD New Orleans MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Monroe	71220	10.67	0	2	D			Open	2
	71291	18.34			D	0	3	Close	
	71201	8.67	6	4	D	6	3	Close	
	71280							Open	2
	71227							Open	2
Little Rock	72015	17.67	2	0	D	2	2		2
	72116		3	0		3	0		
	72205		0	4		0	4		2
	72032	29.66	3	2	D	3	0	Open	2
	72076		3	4		3	4	Close	
	72204		3	0		3	0		
	72022							Open	2
	72023							Open	2

1. NRD Chicago MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Chicago	60901		4	0		4	0	Open	5
	60478		4	0		4	0		
	60473		0	3		0	3	Close	
	60620	21	5	0		5	0	Open	2
	60623	13.34	3	0	D/A	1	0		
	60110		0	4		0	4		2
	60120	13.34	4	2	D	4	0	Open	2
	60506		5	0		5	0	Open	2
	60516	8.33	5	2	D/A	5	3		2
	46360	18.34	2	2	D	2	0	Open	2
	53142		2	0		2	0	Open	2
	60115		2	2		2	2		4
	60915		0	4		0	4	Close	
	60453		4	4		4	4		3
	60411	25.68	5	4		5	4		2
	60462		0	3		0	3	Close	
	60641		4	4		4	4		2
	60426		4	0		4	0	Open	4
	60605		5	0		5	0		
	60617	19.33	2	3	D	0	3		2
	60618		6	4		6	4		2
	60632		5	4		5	4		2
	60201		0	4		0	4		2
	60653		0	3		0	3	Close	

1. NRD Chicago (cont.) MSA	2. Zip Code	3. ASAD Production History	4. Army New Recruiter Optimal RAF	5. Navy New Recruiter Optimal RAF	6. Agree/ Disagree	7. Army Baseline RAF	8. Navy Baseline RAF	9. Station Open/ Close	10. Navy Full Optimal RAF
Chicago	60014		4	4		4	4		2
	60073		3	3		3	3		2
	60194		6	4		6	4		2
	60056		5	2		5	2	Close	
	60085		4	4		4	4		2
	60139		4	3		4	3	Close	
	60435		5	4		5	4		3
	60534		2	3		2	3		2
	60106		0	4		0	4		2
	60160		4	3		4	3		2
	46322		5	5		5	5		3
	46383		4	5		4	5		2
	46410		4	4		4	4	Close	
	53105		2	0		2	0	Open	2
	60505	19.34	0	2	D	0	4		2
	60622	10.99	0	2	D/A	0	4		2
	60608	11.34			D	0	4		2
	60644	7.67			D	0	5		2
	60615	6.34			D	3	0	Open	2
	60067	0.89			D	2	0	Open	2
	60440	23.67			D	2	0		
	60441	16	0	2	D			Open	2
	60639	17.66	2	0	D			Open	2
	60625	13.34	0	2	D			Open	2
	60187	14.67	2	2	D			Open	2
	60466							Open	3
	60477							Open	2
	60050							Open	2
	60629		0	2	D			Open	2
	60123							Open	2
	60103							Open	2
	60016							Open	2
	60099							Open	2
	46307							Open	2
	46368							Open	2
	60805		0	5		0	5	Close	

APPENDIX E: RSLES TWO-SERVICE MODEL

```
* Optimization model that supports the Recruit Station Location Evaluation
* System, a decision support system for DoD recruiting commands.

$TITLE  RECRUIT STATION LOCATION MODEL (2 service version)
$INLINECOM { }

$OFFSYMLIST  OFFSYMXREF
$OFFLISTING

OPTIONS

 LIMCOL = 0,  LIMROW = 0,  SOLPRINT = OFF,  OPTCR = 1e-2,
 MIP = cplex,  SYSOUT = OFF,  RESLIM = 36000,  ITERLIM = 200000;

*******************************************************************
*  SETS AND TABLES
********************************************************************

SETS

      svc   2 services /
      army    'army'
      navy    'navy' /

      a    attributes /
      lat    'latitude of zip code'
      long    'longitude of zip code'
      llat    'latitude of station'
      llong   'longitude of station'
      lpop    'population in station zip code'
      pop     '17-21 year old population'
      smales  'senior hs males'
      hs1     'dummy: one high school in zip code'
      hs2     'dummy: >1 high school in zip code'
      urate    'unemployment rate'
      urban   'urban zip'
      rural    'rural zip'
      income'per capita income'
      density 'pop density'
```

```
    aadjust 'army battalion adjustment'
    nadjust 'navy district adjustment'
    arec    'current number of Army recruiters'
    nrec    'current number of Navy recruiters'
    azip    'Army station in zip code'
    nzip    'Navy station in zip code'
    jzip    'Joint zip code'
    costj2  'Two stations in zip code'
    costj3  'Three stations in zip code'
    area    'area of zip code in square miles'
    coststa 'annual cost of station'
    costusa 'annual cost for army station'
    costusn 'annual cost for navy station'
    costrec 'annual cost per recruiter'
    astatus 'status of army station'
    nstatus 'status of navy station' /

  outrpt 'dummy names for output report'
      /armysta, navysta, jointsta,
          armyrec, navyrec,
          armyzip, navyzip,
          armyrsprod, navyrsprod /

    sta(a)  'station info'
      /llong, llat, arec, nrec,
          lpop, astatus, nstatus /

    cst(a)  'cost info'
          /coststa, costusa, costusn, costrec, costj2 /

    i(a)    'zip code info'
        /long, lat, pop, hs1, hs2, azip, nzip, jzip, area,
          density, income, urate, urban, rural, Aadjust, Nadjust, Smales /

    zc      'zip codes' /
$include %1.zpi
/
    loc(zc) 'locations for stations' /
$include %1.sti
/

    k       'index for break points'
```

```
            /0,1,2,3,4/

      inc(k)  'increment number between kth and (k-1)st breakpoint'
            /1,2,3,4/

;

TABLE

      inzip(zc,i)    'information on zip codes'
$include %1.zpd
;

TABLE

      inloc(loc,sta)  'information on station locations'
$include %1.std
;

TABLE

      cost(loc,cst)  'information on station costs'
$include %1.cst
;

PARAMETER stacost(svc,loc) ;

* Put some isolated scalars into an array ...
loop(loc,
      stacost('army',loc) = cost(loc,'costusa') ;
      stacost('navy',loc) = cost(loc,'costusn') ;
);

PARAMETER zipadjust(svc,zc) ;
loop(zc,
      zipadjust('army',zc) = inzip(zc,'Aadjust') ;
      zipadjust('navy',zc) = inzip(zc,'Nadjust') ;
);

PARAMETER
    soln(zc,outrpt)    'dummy parameter for output report'
    numzc(zc)        'dummy parameter for output report'
```

```
/
$include zzz.zpi
/
     numloc(loc)      'dummy parameter for output report'
/
$include zzz.sti
/
;


alias(svc,s1,s2) ;


*********************************************************************
* PARAMETERS AND SCALARS
*********************************************************************

PARAMETERS

* Betas from the econometric production model.

     incpt(svc)  'intercept'
          / army   0.328731,
            navy   0.091163 /,

     qtr(svc)    'quarterly adjust'
          / army   0.0549112,
            navy   0.037784 /,

     trend(svc)    'trend correction'
          / army   -0.026494,
            navy   -0.030849 /,

     b_smales(svc)    'senior males'
          / army   0.001691,
            navy   0.001353 /,

       b_urban(svc)   'urban'
               / army  0.029706,
                 navy  0.088193 /,

       b_rural(svc) 'rural'
```

```
        / army  -0.221398,
          navy  -0.116747 /,

  b_income(svc) 'per capita income'
        / army  -0.000008586,
          navy  -0.000002946 /,

  b_area(svc)     'zip code area'
        / army  0.000068119,
          navy  0.000029468 /,

  b_shxpop(svc) 'svc share X population'
    / army        0.000020717,
      navy        0.000016336 /,

  b_shxsmale(svc)          'svc share X senior males'
    / army        -0.000067630,
      navy        -0.000368 /,

b_shxurb(svc)      'share-urban interaction'
    / army  0.208255,
      navy  0.0 /,

b_jsta2(svc)   'joint station 2 services'
    / army  -0.144767,
      navy  -0.057164 /,

  b_stxpop(svc) 'station-pop interaction'
    / army  -0.000117,
      navy  -0.000069194 /,

  b_stxsmale(svc)          'station-smales interaction'
    / army  0.000608,
      navy  0.000371 /,

  b_stxurb(svc)  'station-urban interaction'
    / army  -0.309312,
      navy  -0.101549 /,

  b_stxrural(svc)          'station-rural interaction'
    / army  -0.406322,
      navy  0.0 /;
```

```
TABLE

      b_dist(s1,s2)   'dist to s1 station on s2 prod'
                        army          navy
                army  -0.000880      -0.000640
                navy  -0.000240      -0.000231 ;

TABLE

      b_sh(s1,s2)     's1 share on s2 prod'
                        army          navy
                army  0.780632       0.259271
                navy  -0.011199      0.465457 ;


TABLE

      b_sh2(s1,s2)    's1 share squared on s2 prod'
                        army         navy
                army  -0.100200      0.0
                navy  0.0            -0.093643 ;

TABLE

    b_sta(s1,s2)   's1 station in zip code on s2 production'
              army          navy
        army   0.631327   0.144450
        navy   0.412761   0.378876 ;

*** End betas ***

PARAMETER

      distcost(svc)  'for distance cost calculations'
              / army   0.212885,
                navy   0.212885 /;

PARAMETER

* These values are used to construct a piecewise-linear approximation
* of the non-linear (quadratic) production function.
```

```
   VALUE(k)    'kth breakpoint value'
         /0    0,
          1    0.25,
          2    0.5,
          3    1.0,
          4    2.0/ ;

PARAMETER

        SLOPE(k)      'slope of kth line segment';
*       kth line segment between VALUE(k) and VALUE(k-1)
        SLOPE(k)$(inc(k)) = ( (VALUE(k)*VALUE(k)) - (VALUE(k-1)*VALUE(k-1))
)/
                 (VALUE(k) - VALUE(k-1))
;

PARAMETER

* Actually, defined later.... Set to zero for now.

      budget(svc)
       /army 0,
        navy 0 /
;

PARAMETER
        target(svc)
/
$include %1.tgt
/ ;


PARAMETER weight(svc);
* Can be used to weight importance of obtaining recruits for a particular
* service. Under normal circumstances, the budgets should provide the right
* balance, and so we set the values to 1.
weight('army') = 1 ;
weight('navy') = 1 ;

SCALAR  milecost 'cost per mile of travel' /0.31/ ;
SCALAR  maxsh    'max share per zip'  /2/ ;
```

```
PARAMETER  minstas(svc)  'min total stations for svc';
        minstas('army') = 0 ;
        minstas('navy') = 0 ;
PARAMETER  maxstas(svc)  'max total stations for svc';
        maxstas('army') = 100 ;
        maxstas('navy') = 100 ;

PARAMETER  mintotrecs(svc)  'min total recs for svc';
        mintotrecs('army') = 0 ;
        mintotrecs('navy') = 0 ;
PARAMETER  maxtotrecs(svc)  'max total recs for svc';
        maxtotrecs('army') = 250 ;
        maxtotrecs('navy') = 250 ;

PARAMETER  minstarecs(svc)  'min recs per sta for svc';
        minstarecs('army') = 2 ;
        minstarecs('navy') = 2 ;
PARAMETER  maxstarecs(svc)  'max recs per sta for svc';
        maxstarecs('army') = 8 ;
        maxstarecs('navy') = 4 ;

PARAMETER  rtrunc(svc,loc);

***********************************************************************
*  DISTANCE CALCULATIONS
***********************************************************************

SCALAR  pi  /3.14159265/ ;

SCALAR

        radconv  'radian conversion constant';
        radconv = 57.29578;

PARAMETERS

        aa(zc,loc)   'first step in distance calculation'
        d(zc,loc)    'distance from zip to station location';

        aa(zc,loc) = ( sin( inzip(zc,'lat')/radconv ) *
         sin( inloc(loc,'llat')/radconv ) +
```

```
     cos( inzip(zc,'lat')/radconv ) *
     cos( inloc(loc,'llat')/radconv ) *
    cos(abs(inzip(zc,'long') - inloc(loc,'llong'))/radconv )) ;
     d(zc,loc) = 3959 * arctan(sqrt(abs( 1-sqr(aa(zc,loc)) )/
          aa(zc,loc)));
     d(zc,loc)$( (inzip(zc,'lat') eq inloc(loc,'llat')) and
     (inzip(zc,'long') eq inloc(loc,'llong')) )
     = sqrt( inzip(zc,'area')/pi )/2;

display budget ;

**********************************************************************
* COMPUTE BUDGETS
* The model maximizes production subject to a budget constraint.
* Here we calculate the budget corresponding to the _current_ allocation
* of recruiters and stations, including an estimate for distance cost.
**********************************************************************
SCALAR coststa_a /0/;
SCALAR coststa_n /0/;

SCALAR costrec_a /0/;
SCALAR costrec_n /0/;

SCALAR costdist_a /0/;
SCALAR costdist_n /0/;

SCALAR numsta_a /0/;
SCALAR numsta_n /0/;

SCALAR numrec_a /0/;
SCALAR numrec_n /0/;

SCALAR numjoint2 /0/ ;

SCALAR jointcost2 /0/ ;

* Find the number of stations and recruiters for each service, in the
* current allocation.
loop( loc,
  jointcost2 = cost(loc,'costj2') ;
  if( inloc(loc,'nrec') > 0,
        numsta_n = numsta_n + 1 ;
```

```
        coststa_n = coststa_n + cost(loc,'costusn') ;
        numrec_n = numrec_n + inloc(loc,'nrec') ;
        costrec_n = costrec_n + cost(loc,'costrec')*inloc(loc,'nrec') ) ;
   if( inloc(loc,'arec') > 0,
        numsta_a = numsta_a + 1 ;
        coststa_a = coststa_a + cost(loc,'costusa') ;
        numrec_a = numrec_a + inloc(loc,'arec') ;
        costrec_a = costrec_a + cost(loc,'costrec')*inloc(loc,'arec') ) ;
   if( ((inloc(loc,'arec') > 0) and (inloc(loc,'nrec') > 0)) ,
        numjoint2 = numjoint2 + 1 ) ;
) ;

* Now estimate the distance cost of the current configuration by making a
* territory assignment and using the regression equation...

SCALAR bestdist_n 'best distance' /10000/;
SCALAR bestdist_a 'best distance' /10000/;
PARAMETER YY(svc,zc,loc) ;
loop(zc,
        bestdist_n=10000;
        bestdist_a=10000;
        loop(loc,
                YY(svc,zc,loc)=0;
                if (( inloc(loc,'nrec')>0 and d(zc,loc)<bestdist_n),
                        bestdist_n=d(zc,loc));
                if (( inloc(loc,'arec')>0 and d(zc,loc)<bestdist_a),
                        bestdist_a=d(zc,loc));
        );
        YY('army',zc,loc)$(d(zc,loc)=bestdist_a)=1;
        YY('navy',zc,loc)$(d(zc,loc)=bestdist_n)=1;
);


costdist_a = milecost * sum( (zc,loc), distcost('army') * d(zc,loc) *
          inzip(zc,'pop') * YY('army',zc,loc) );
costdist_n = milecost * sum( (zc,loc), distcost('navy') * d(zc,loc) *
          inzip(zc,'pop') * YY('navy',zc,loc) );

* Compute the total budget for each service. Note that the savings for
* having joint stations is evenly divided among services, even though a
* service may not currently be an equal participant in collocation.
```

```
budget('army') = costrec_a + coststa_a + jointcost2*numjoint2 + costdist_a ;
budget('navy') = costrec_n + coststa_n + jointcost2*numjoint2 + costdist_n ;

display numsta_a ;
display numrec_a ;
display numsta_n ;
display numrec_n ;
display numjoint2 ;
display costdist_a ;
display costdist_n ;
display coststa_a ;
display coststa_n ;
display costrec_a ;
display costrec_n ;

**********************************************************************
* VARIABLES
**********************************************************************

BINARY VARIABLE

    X(svc,loc)       one if station loc occupied by service svc
    Y1(svc,zc,loc)   one if zc assigned to station loc by svc
    R1(svc,loc)      one if one recruiter of svc added to loc
    W2(loc)          one if a 2-service joint station
;

POSITIVE VARIABLE

    Y(svc,zc,loc)     fraction of zc assigned to station loc by svc
    R(svc,loc)        recruiters of svc assigned to station loc
    RNEW(svc,loc)     new recruiter value of svc in loc
    SH(svc,zc,loc)    recruiter share
    SH2(svc,zc,loc)   recruiter share squared
    SHINC(k,svc,zc,loc) percentage of kth increment (line segment)
;

FREE VARIABLE

    zprod          objective function value
    zrecr          objective function value
;
```

```
*********************************************************************
* EQUATIONS
*********************************************************************

EQUATIONS

        prodn       'objective function'
        prody       'objective function with integer y'
        totcost     'total cost constraint'
        totcosty    'total cost constraint with integer y'
        costintrec  'total cost constraint with integer y and recs'
        recruiter   'the objective function for min recrs'
        shdef       'definition of share'
        sh2def      'definition of share squared'
        zipopen     'ensures zips assigned to open stations only'
        zipopeny    'ensures zips assigned to open stations only (int y)'
        zipstation  'ensures zips assigned to only one station'
        zipstay     'ensures zips assigned to only one station (int y)'
        totshare    'ensures tot shares do not exceed tot recrs'
        intrec      'ensures new recr. is trun(oldreclevel)+1'
        totshint    'ensures tot shares do not exceed tot recrs'
        maxshare    'ensures rec share less than one'
        maxsharey   'ensures rec share less than one (int y)'
        minrectot      'min total recruiters'
        maxrectot      'max total recruiters (integer)'
        minrectoti     'min total recruiters'
        maxrectoti     'max total recruiters (integer)'
        minrecsta      'min total recruiters per station'
        minrecstai     'min total recruiters per station (integer)'
        maxrecsta      'max total recruiters per station'
        maxrecstai     'max total recruiters per station (integer)'
        minsta      'ensures at least minimum number of stations for svc'
        maxsta      'ensures no more than max number of stations for svc'
        joint2      'enforces joint variable'
        joint21     'enforces joint variable'
        shincmax    'max value share increment can have'
;

prodn.. zprod =e=
        sum( svc, weight(svc) *
```

```
    sum( zc,  incpt(svc) + qtr(svc) + trend(svc) + zipadjust(svc,zc)
            + b_income(svc)*inzip(zc,'income')
            + b_smales(svc)*inzip(zc,'smales')
            + b_urban(svc)*inzip(zc,'urban')
            + b_rural(svc)*inzip(zc,'rural')
            + b_area(svc)*inzip(zc,'area')

            + sum( loc,
                    ( b_shxpop(svc)*inzip(zc,'pop')
                    + b_shxsmale(svc)*inzip(zc,'smales')
                    + b_shxurb(svc)*inzip(zc,'urban')
                    )*SH(svc,zc,loc)

                    + sum( s1,
                            b_sh(s1,svc)*SH(s1,zc,loc)
                          + b_sh2(s1,svc)*SH2(s1,zc,loc) ) ) )

    + sum( loc,
            ( b_stxsmale(svc)*inzip(loc,'smales')
            + b_stxurb(svc)*inzip(loc,'urban')
            + b_stxrural(svc)*inzip(loc,'rural')
            )*X(svc,loc)

            + sum( (s1,zc), b_dist(s1,svc)*d(zc,loc)*Y(s1,zc,loc) )
            + sum( s1, b_sta(s1,svc)*X(s1,loc) )
            + b_jsta2(svc)*W2(loc) ) ) ;

prody.. zprod =e=
    sum( svc, weight(svc) *
    sum( zc,  incpt(svc) + qtr(svc) + trend(svc) + zipadjust(svc,zc)
            + b_income(svc)*inzip(zc,'income')
            + b_smales(svc)*inzip(zc,'smales')
            + b_urban(svc)*inzip(zc,'urban')
            + b_rural(svc)*inzip(zc,'rural')
            + b_area(svc)*inzip(zc,'area')

            + sum( loc,
                    ( b_shxpop(svc)*inzip(zc,'pop')
                    + b_shxsmale(svc)*inzip(zc,'smales')
                    + b_shxurb(svc)*inzip(zc,'urban')
                    )*SH(svc,zc,loc)
```

```
                + sum( s1,
                        b_sh(s1,svc)*SH(s1,zc,loc)
                      + b_sh2(s1,svc)*SH2(s1,zc,loc) ) ) )

    + sum( loc,
          ( b_stxsmale(svc)*inzip(loc,'smales')
          + b_stxurb(svc)*inzip(loc,'urban')
          + b_stxrural(svc)*inzip(loc,'rural')
          )*X(svc,loc)

          + sum( (s1,zc), b_dist(s1,svc)*d(zc,loc)*Y1(s1,zc,loc) )
          + sum( s1, b_sta(s1,svc)*X(s1,loc) )
          + b_jsta2(svc)*W2(loc) ) ) ;

totcost(svc)..  sum( loc,
                stacost(svc,loc)*X(svc,loc) +
                cost(loc,'costj2')*W2(loc)+
          cost(loc,'costrec')*R(svc,loc) ) +
          milecost * sum( (loc,zc), distcost(svc)*
                 d(zc,loc)*inzip(zc,'pop')*Y(svc,zc,loc) )
                      =l= budget(svc) ;

totcosty(svc).. sum( loc,
                stacost(svc,loc)*X(svc,loc) +
                cost(loc,'costj2')*W2(loc) +
          cost(loc,'costrec')*R(svc,loc) ) +
                milecost * sum( (zc,loc), distcost(svc) * d(zc,loc) *
      inzip(zc,'pop') * Y1(svc,zc,loc) )
                      =l= budget(svc) ;

costintrec(svc).. sum( loc,
                stacost(svc,loc)*X(svc,loc) +
                cost(loc,'costj2')*W2(loc)+
                cost(loc,'costrec')*RNEW(svc,loc) ) +
          milecost * sum( (zc,loc), distcost(svc) * d(zc,loc) *
    inzip(zc,'pop') * Y1(svc,zc,loc) )
                      =l= budget(svc) ;

recruiter..  zrecr =e= sum ( (svc,loc), R1(svc,loc));

shdef(svc,zc,loc)..  SH(svc,zc,loc) =e= sum( k$(inc(k)), SHINC(k,svc,zc,loc) );
```

```
sh2def(svc,zc,loc).. SH2(svc,zc,loc) =e= sum( k$(inc(k)),
                                    SLOPE(k)*SHINC(k,svc,zc,loc) );


zipopen(svc,zc,loc).. Y(svc,zc,loc) =l= X(svc,loc) ;
zipopeny(svc,zc,loc).. Y1(svc,zc,loc) =l= X(svc,loc) ;

zipstation(svc,zc).. sum( loc, Y(svc,zc,loc) ) =e= 1 ;
zipstay(svc,zc).. sum( loc, Y1(svc,zc,loc) ) =e= 1 ;

totshare(svc,loc).. sum( zc, SH(svc,zc,loc) ) =e= R(svc,loc) ;
totshint(svc,loc).. sum( zc, SH(svc,zc,loc) ) =e= RNEW(svc,loc) ;

intrec(svc,loc).. RNEW(svc,loc) =e= rtrunc(svc,loc) + R1(svc,loc);

maxshare(svc,zc,loc).. SH(svc,zc,loc) =l= maxsh*Y(svc,zc,loc) ;
maxsharey(svc,zc,loc).. SH(svc,zc,loc) =l= maxsh*Y1(svc,zc,loc) ;

minrecsta(svc,zc,loc).. minstarecs(svc)*X(svc,loc) =l= R(svc,loc) ;
maxrecsta(svc,zc,loc).. maxstarecs(svc)*X(svc,loc) =g= R(svc,loc) ;
minrecstai(svc,zc,loc).. minstarecs(svc)*X(svc,loc) =l= RNEW(svc,loc) ;
maxrecstai(svc,zc,loc).. maxstarecs(svc)*X(svc,loc) =g= RNEW(svc,loc) ;

minrectot(svc).. sum( loc, R(svc,loc) ) =g= mintotrecs(svc) ;
maxrectot(svc).. sum( loc, R(svc,loc) ) =l= maxtotrecs(svc) ;
minrectoti(svc).. sum( loc, RNEW(svc,loc) ) =g= mintotrecs(svc) ;
maxrectoti(svc).. sum( loc, RNEW(svc,loc) ) =l= maxtotrecs(svc) ;

minsta(svc).. sum(loc, X(svc,loc)) =g= minstas(svc) ;
maxsta(svc).. sum(loc, X(svc,loc)) =l= maxstas(svc) ;

joint2(loc).. sum(svc, X(svc,loc)) - 2*W2(loc) =g= 0 ;

joint21(loc).. sum(svc, X(svc,loc)) - 2*W2(loc) =l= 1 ;

shincmax(k,svc,zc,loc)$(inc(k)).. SHINC(k,svc,zc,loc) =l=
                         VALUE(k) - VALUE(k-1) ;


*********************************************************************
* DEFINE THE STATION ALLOCATION MODELS
*********************************************************************
```

```
Model PICKLOCS
  /prodn,totcost,shdef,sh2def,zipopen,zipstation,totshare,maxshare,
        minsta,maxsta,minrecsta,maxrecsta,minrectot,maxrectot,
        joint2,joint21,shincmax/ ;

Model PICKLOCSY
  /prody,totcosty,shdef,sh2def,zipopeny,zipstay,totshare,maxsharey,
        minsta,maxsta,minrecsta,maxrecsta,minrectot,maxrectot,
        joint2,shincmax/ ;

************************************************************************
* DEFINE THE INTEGER RECRUITER MODEL
************************************************************************

Model PICKRECRS
  /prody,costintrec,shdef,sh2def,zipopeny,zipstay,totshint,maxsharey,
        minsta,maxsta,minrecsta,maxrecsta,minrectot,maxrectot,
        joint2,shincmax,intrec/ ;

************************************************************************
* FIX STATIONS AND RECRUITERS ACCORDING TO USER INPUT
* If the station status (based on .std file) is 2, X is free; if
* status is 0, fix X=0 (station closed); if status is 1, fix X=1
* (station open) and fix number of recruiters to 'xrec' value.
************************************************************************

loop( loc,
  If( inloc(loc,'Astatus')<> 2,
    X.fx('army',loc) = inloc(loc,'astatus');
    if ( inloc(loc,'Astatus') = 1,
              R.fx('army',loc) = inloc(loc,'arec') );
  );
  If( inloc(loc,'Nstatus') <> 2,
    X.fx('navy',loc) = inloc(loc,'nstatus');
    if ( inloc(loc,'Nstatus') = 1,
              R.fx('navy',loc) = inloc(loc,'nrec') );
  );
);

************************************************************************
* SOLVE THE MIP MODEL TO PICK LOCATIONS
```

```
*******************************************************************
 picklocs.optfile=1;

 Solve PICKLOCS using mip maximizing zprod ;

*******************************************************************
* Make a single-source territory assignment
* The algorithm is to fix station locations based on PICKLOCS model,
* and fix all territory variables (Y's) that were zero or one.  Then
* solve for the remaining territory variables by near-station rule.
*******************************************************************

* First, fix the W's and location variable X's from the solution.

W2.fx(loc)=W2.l(loc);
X.fx(svc,loc)=X.l(svc,loc);

* Fix Y1's to 1 if Y's were 1 in the relaxed solution, otherwise use
* the nearest-station heuristic.

SCALAR counter /0/ ;
SCALAR flag /0/ ;
SCALAR bestdist /10000/ ;
PARAMETER best(svc,zc,loc) ;
loop(svc,
        loop(zc,
                flag = 0 ;
                bestdist = 10000 ;
                loop(loc,
                        if ( not flag,
                                if ( (Y.l(svc,zc,loc) = 1),
                                        bestdist=d(zc,loc);
                                        Y1.fx(svc,zc,loc) = 1;
                                        flag = 1 ;
                                        counter = counter + 1 ;
                                else
                                        if (( X.l(svc,loc)=1 and
                                                d(zc,loc)<bestdist),
                                                bestdist=d(zc,loc));
                                ) ;
                        ) ;
                );
```

```
            if ( not flag, Y1.fx(svc,zc,loc)$(d(zc,loc)=bestdist)=1 );
      );
);

display counter ;

* Now solve using integer Y1's for remaining zip codes.

picklocsy.optfile=1;
Solve PICKLOCSY using mip maximizing zprod;

*********************************************************************
* SOLVE THE MIP MODEL TO PICK RECRUITERS
*********************************************************************

* First, fix all Y1's (X's and W's already fixed).

Y1.fx(svc,zc,loc) = Y1.l(svc,zc,loc) ;

rtrunc(svc,loc) = trunc(R.l(svc,loc));

Solve PICKRECRS using mip maximizing zprod ;

*********************************************************************
* Calculate and display final cost to each service
*********************************************************************

PARAMETERS
        coststa
        costsvc
        costrec
        costdist
        totlcost;
        coststa  = 0;
   costsvc  = sum( loc, cost(loc,'costusa')*X.l('army',loc)
                        + cost(loc,'costusn')*X.l('navy',loc)
                        + cost(loc,'costj2')*W2.l(loc) );
   costrec  = sum( (svc,loc), cost(loc,'costrec')*RNEW.l(svc,loc) );
   costdist = milecost * sum( (svc,zc,loc), distcost(svc) * d(zc,loc) *
          inzip(zc,'pop') * Y1.l(svc,zc,loc) );
      totlcost = coststa + costsvc + costrec ;
```

```
*display coststa;
*display costsvc;
*display costrec;
*display costdist;
display totlcost;

***************************************************************************
* Calculate and display final production
***************************************************************************

PARAMETER prodtest1(svc) ;
prodtest1(svc) =
        4* ( sum( zc,  incpt(svc) + qtr(svc) + trend(svc) + zipadjust(svc,zc)
                + b_income(svc)*inzip(zc,'income')
                + b_smales(svc)*inzip(zc,'smales')
                + b_urban(svc)*inzip(zc,'urban')
                + b_rural(svc)*inzip(zc,'rural')
                + b_area(svc)*inzip(zc,'area')

                + sum( loc,
                        ( b_shxpop(svc)*inzip(zc,'pop')
                        + b_shxsmale(svc)*inzip(zc,'smales')
                        + b_shxurb(svc)*inzip(zc,'urban')
                        )*SH.l(svc,zc,loc)

                        + sum( s1,
                                b_sh(s1,svc)*SH.l(s1,zc,loc)
                              + b_sh2(s1,svc)*SH2.l(s1,zc,loc) ) ) )

        + sum( loc,
                ( b_stxsmale(svc)*inzip(loc,'smales')
                + b_stxurb(svc)*inzip(loc,'urban')
                + b_stxrural(svc)*inzip(loc,'rural')
                )*X.l(svc,loc)

                + sum( (s1,zc), b_dist(s1,svc)*d(zc,loc)*Y1.l(s1,zc,loc) )
                + sum( s1, b_sta(s1,svc)*X.l(s1,loc) )
                + b_jsta2(svc)*W2.l(loc) ) ) ;

display prodtest1 ;

***************************************************************************
```

```
* Calculate and display final production for each svc,zc and loc.
* The production function is for one quarters production so it is
* converted to annual production.
**********************************************************************

PARAMETER prodperzc1(zc,svc) 'production per zc per service';
PARAMETER pplocsta1(loc,svc) 'prod. for having a station in the zc per svc';
PARAMETER pploczc1(loc,svc) 'prod. for the zc the station is in per svc';
PARAMETER prodploc1(loc,svc) 'total production for a station per svc';

prodperzc1(zc,svc) =
            4 * (incpt(svc) + qtr(svc) + trend(svc) + zipadjust(svc,zc)
              + b_income(svc)*inzip(zc,'income')
              + b_smales(svc)*inzip(zc,'smales')
              + b_urban(svc)*inzip(zc,'urban')
              + b_rural(svc)*inzip(zc,'rural')
              + b_area(svc)*inzip(zc,'area')

              + sum( loc,
                     ( b_shxpop(svc)*inzip(zc,'pop')
                     + b_shxsmale(svc)*inzip(zc,'smales')
                     + b_shxurb(svc)*inzip(zc,'urban')
                     )*SH.l(svc,zc,loc)

                     + sum( s1,
                              b_sh(s1,svc)*SH.l(s1,zc,loc)
                            + b_sh2(s1,svc)*SH2.l(s1,zc,loc) ) ) );
pplocsta1(loc,svc) =

            4 * ( ( b_stxsmale(svc)*inzip(loc,'smales')
              + b_stxurb(svc)*inzip(loc,'urban')
              + b_stxrural(svc)*inzip(loc,'rural')
              )*X.l(svc,loc)

              + sum( (s1,zc), b_dist(s1,svc)*d(zc,loc)*Y1.l(s1,zc,loc) )
              + sum( s1, b_sta(s1,svc)*X.l(s1,loc) )
              + b_jsta2(svc)*W2.l(loc) ) ;

pploczc1(loc,svc) = sum( zc, prodperzc1(zc,svc)$(Y1.l(svc,zc,loc)=1));

*negative production in a zip code doesn't make sense but is possible
*given some of the negative betas so the next loop sets prodploc1 to
```

```
*zero if production is negative.
Loop((zc,svc),
  If ( prodperzc1(zc,svc) < 0,
    prodperzc1(zc,svc)=0;
  );
);

prodploc1(loc,svc) = (pplocsta1(loc,svc) + pploczc1(loc,svc)) ;

*negative production in a station doesn't make sense but is possible
*given some of the negative betas so the next loop sets prodploc1 to
*zero if production is negative.
Loop((loc,svc),
  If ( prodploc1(loc,svc) < 0,
    prodploc1(loc,svc)=0;
  );
);

display prodperzc1 ;
display pplocsta1 ;
display pploczc1 ;
display prodploc1 ;

**********************************************************************
* Display the results
**********************************************************************

display X.l, W2.l, Y1.l, R.l, RNEW.L, SH.l;

**********************************************************************
* PRINT REPORT FOR FINAL RESULTS
**********************************************************************
File report / STATIONS.txt / {define put filename  REPORT} ;
Put  report          {open REPORT} ;
report.pw=160;
Put 'zip_code,' ;
Put 'armysta,';
Put 'navysta,';
Put 'jointsta,';
Put 'armyrec,';
Put 'navyrec,';
Put 'armyzip,';
```

```
Put 'navyzip,';
Put 'armyprod,';
Put 'navyprod,';
Put 'armyrsprod,';
Put 'navyrsprod,';
Loop( zc,
  Loop( loc,
    If ( numzc(zc) = numloc(loc),
      soln(zc,'armysta') = X.l('army',loc);
      soln(zc,'navysta') = X.l('navy',loc);
      If ( X.l('army',loc)=1 and X.l('navy',loc)=1,
        soln(zc,'jointsta')=1;
      Else
        soln(zc,'jointsta')=0;
      );
      soln(zc,'armyrec') = RNEW.l('army',loc);
      soln(zc,'navyrec') = RNEW.l('navy',loc);
      If ( W2.l(loc) = 1,
        soln(zc,'armyrsprod')=prodploc1(loc,'army');
        soln(zc,'navyrsprod')=prodploc1(loc,'navy');
      Elseif ( X.l('army',loc)=1) ,
        soln(zc,'armyrsprod')=prodploc1(loc,'army');
        soln(zc,'navyrsprod')=0;
      Elseif ( X.l('navy',loc)=1) ,
        soln(zc,'navyrsprod')=prodploc1(loc,'navy');
        soln(zc,'armyrsprod')=0;
      );

    );
    If ( Y1.l('army',zc,loc)=1,
      soln(zc,'armyzip')=numloc(loc);
    );
    If ( Y1.l('navy',zc,loc)=1,
      soln(zc,'navyzip')=numloc(loc);

    );
  );
);
Loop(zc,
  Put /;
  Put "";
  Put zc.tl;
```

```
Put @7 '"';
Put ',';
Put soln(zc,'armysta'):0:0;
Put ',';
Put soln(zc,'navysta'):0:0;
Put ',';
Put soln(zc,'jointsta'):0:0;
Put ',';
Put soln(zc,'armyrec'):0:0;
Put ',';
Put soln(zc,'navyrec'):0:0;
Put ',';
Put '"';
Put soln(zc,'armyzip'):0:0;
Put '"';
Put ',';
Put '"';
Put soln(zc,'navyzip'):0:0;
Put '"';
Put ',';
Put prodperzc1(zc,'army'):7:2;
Put ',';
Put prodperzc1(zc,'navy'):7:2;
Put ',';
Put soln(zc,'armyrsprod'):7:2;
Put ',';
Put soln(zc,'navyrsprod'):7:2;

);
Putclose report {close REPORT};
```

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